

Course Structure and Syllabus
BTech. in Computer Science and Engineering
(For Batch 2023 Onward)

**ABV-Indian Institute of Information Technology &
Management, Gwalior**

4 year (8 semester) B.Tech. in Computer Science and Engineering

(Total credits: 171)

SEMESTER -1	Sl no	Course Code	Subjects	Credits	L-T-P
	1	EE101	Fundamentals of Electrical and Electronics	4	3-0-2
	2	ES101	Engineering Physics	4	3-0-2
	3	ES102	Engineering Mathematics	4	3-1-0
	4	EE102	Engineering Design Principles	3	2-0-2
	5	CS101	Principles of Computer Programming	4	3-0-2
	6	HS101	Freshman Skills	2	2-0-0
	7	HS102	Sports and Physical Education	2	0-1-2
		Total	23 Credits		

SEMESTER -2	Sl no	Course Code	Subjects	Credits	L-T-P
	1	EE103	Digital Electronics	4	3-0-2
	2	ES103	Probability and Statistics	4	3-1-0
	3	CS102	Data Structures	4	3-0-2
	4	EE104	Hardware Workshop	3	1-0-4
	5	CS103	Object Oriented Programming	4	3-0-2
	6	HS103	Ecology and Environment Sciences	2	2-0-0
	7	CS104	Mobile Application Technologies	2	0-1-2
		Total	23 credits		
	MO-1 (Optional)		2/3-0-0		

EXIT AFTER YEAR - 1

Certificate in Engineering Sciences (46 credits)

SEMESTER -3	Sl no	Course Code	Subjects	Credits	L-T-P
	1	HS201	Indian Culture, Ethics and Moral Values	2	2-0-0
	2	CS201	Discrete Structures	4	3-1-0
	3	CS202	Computer Organization and Architecture	4	3-0-2
	4	CS203	Design and Analysis of Algorithms	4	3-0-2
	5	CS204	Database Systems	4	3-0-2
	6	CS205	Paradigms of Programming Languages	4	3-0-2
		Total	22 credits		

SEMESTER -4	Sl no	Course Code	Subjects	Credits	L-T-P
	1	MS619	Entrepreneurship and Innovation	2	2-0-0
	2	CS206	Theory of Computation	3	3-0-0
	3	CS207	Operating Systems	4	3-0-2
	4	CS208	Computer Networks	4	3-0-2
	5	CS209	Mathematical Foundations of Computing	4	3-1-0
	6	CS210	Software Engineering	4	3-0-2
				Total	21 credits
	MO-2 (Optional)			2/3-0-0	

EXIT AFTER YEAR - 2

Diploma in Computer Science and Engineering (89 credits)

SEMESTER -5	Sl no	Course Code	Subjects	Credits	L-T-P
	1	MS603	Business Economics	3	3-0-0
	2	CS0XX	Department Elective-1	3	3-0-0
	3	EE206	Microprocessor and Interfacing	4	3-0-2
	4	CS301	Compiler Design	4	3-0-2
	5	CS302	Computer Graphics	4	3-0-2
	6	CS303	Trustworthy Artificial Intelligence	4	3-0-2
			Total	22 credits	

SEMESTER -6	Sl no	Course Code	Subjects	Credits	L-T-P
	1	ENXXX	Art of Engineering Research	2	2-0-0
	2		Multidisciplinary/Open Elective- 1/MOOC 1	3	3-0-0
	3	CS0XX	Department Elective-2	3	3-0-0
	4	CS305	Optimization Techniques	4	3-1-0
	5	CS306	Machine Learning	4	3-0-2
	6	CS307	Information Security Systems	4	3-0-2
			Total	20 credits	

Colloquium of 3 credits in summer semester (MOOC, NPTEL etc. in lieu of colloquium)

EXIT AFTER YEAR - 3

BSc in Computer Science and Engineering (131 credits)

SEMESTER -7	Sl no	Course Code	Subjects	Credits	L-T-P
	1		Multidisciplinary/Open Elective- 2/MOOC 2	3	3-0-0
	2	CS0XX	Department Elective -3	3	3-0-0
	3	CS401	Natural Language Processing	4	3-0-2
	4	CS402	Digital Image Processing	4	3-0-2
	5	CS403	Cloud Computing	4	3-0-2
	6	CS404	Big Data Analytics	4	3-0-2
	7	CS498	Colloquium (Based on industrial training)/MOOC	3	0-0-6
			Total	25 credits	

SEMESTER - 8	Sl no	Course Code	Subjects	Credits	L-T-P
	1	CS499	BTech Project/Internship	12	0-0-24
	2		Multidisciplinary/Open Elective- 3/MOOC 3	3	3-0-0
			Total	15 credits	

FINAL EXIT AFTER YEAR – 4

BTech. In Computer Science and Engineering (171 credits)

Minor in CSE (23 credits)

SN	Subject	CODE	L-T-P	Credits
1	Design and Analysis of Algorithms	CS203	3-0-2	4
2	Database Systems	CS204	3-0-2	4
3	Operating Systems	CS207	3-0-2	4
4	Computer Networks	CS208	3-0-2	4
5	Software, System Analysis and Design	CS0XX	3-0-2	4
6	CSE Elective Course	CS0XX	3-0-0	3

NOTE:

A candidate from CSE can receive a Minor Degree in EEE/Mathematics & Scientific Computing if he/she earns the prescribed credits (Over and above) the credits prescribed by the respective major programme.

A Minor in Computer Science is open to student(s) from other discipline subject to successful completion of the above credits with a minimum of 6 CGPA. A student can opt for the courses depending on the convenience. For example: CS207 and CS210 are offered in 4th semester. A student can opt for these courses along with his regular courses in 4th semester OR he can take one of the two courses in 4th semester and the other in his 6th semester. This reduces the credit load in a particular semester. In addition, if a given course is floated in summer semester, the student can also opt for the same in summer semester.

B.Tech (CSE) Department Elective Courses

SN	Subject	Code	L-T-P	Credits
1	Graph Theory	CS001	3-0-0	3
2	Software, System Analysis and Design	CS002	3-0-2	4
3	Digital Signal Processing	CS003	3-0-0	3
4	Data Analytics and Visualisation	CS004	3-0-0	3
5	Cryptography and Network Security	CS005	3-0-0	3
6	Control System Engineering	CS006	3-0-0	3
7	System Simulation and Modeling	CS007	3-0-0	3
8	IoT Protocols	CS008	3-0-0	3
9	Game Programming	CS009	3-0-0	3
10	Formal languages and Automata	CS010	3-0-0	3
11	Advanced Network Technologies	CS011	3-0-0	3
12	Empirical Techniques in Software Engineering	CS012	3-0-0	3
13	Digital Water Marking and Steganalysis	CS013	3-0-0	3
14	Deep Learning	CS014	3-0-0	3
15	Blockchain Technology	CS015	3-0-0	3
16	Introduction to Robotics	CS016	3-0-0	3
17	Stochastic Processes and Queuing Theory	CS017	3-0-0	3
18	Advanced Competitive Programming	CS018	3-0-0	3

19	Network Programming	CS019	3-0-0	3
20	Combinatorial Mathematics	CS020	3-0-0	3
21	Network Design and Optimization	CS021	3-0-0	3
22	Software reliability	CS022	3-0-0	3
23	Computer Vision	CS023	3-0-0	3
24	Recommender Systems	CS024	3-0-0	3
25	Modern Cryptography	CS025	3-0-0	3
26	Robot Motion Planning	CS026	3-0-0	3
27	Nature Inspired Computing	CS027	3-0-0	3
28	Game Theory and Applications	CS028	3-0-0	3
29	Human – Computer Interaction	CS029	3-0-0	3
30	Randomized Algorithms	CS030	3-0-0	3

SYLLABUS

1	Code of the subject	EE101
2	Title of the subject	Fundamentals of Electrical and Electronics
3	Prerequisite	NA
4	L-T-P	3-0-2
5	Learning Objectives of the subject	<p>After the completion of the course, the students will be able to:</p> <ul style="list-style-type: none"> • Demonstrate the use of semiconductor diodes in various applications. • Discuss and explain the working of transistors, their configurations and applications. • Apply networks laws and theorems to solve electric circuits. • Analyze transient and steady state response of DC circuits. • Explain and analyse the behaviour of transformer. • Elucidate the principle and characteristics of DC motor and DC generator.
6	Brief Contents	<p>Fundamental laws of electrical engineering circuit parameters, Classification of devices of an electrical circuit; Basic devices: resistors, controlled sources, diodes, capacitors and inductors, ideal transformers, Methods of Analysis, DC Network Theorems, Basic circuit analysis methods: nodal, mesh and modified nodal-analysis; Transient analysis of RL, RC, and RLC circuits, Three Phase Circuits and Power Measurements, Single Phase Transformers, Three Phase Induction Machines, DC Machines</p> <p>Semiconductor Materials: Ge, Si, and GaAs; n-Type and p-Type Materials; Semiconductor Diode and types; Construction and application of Bipolar Junction Transistors; Common-Base Configuration, Common-Emitter Configuration, Common-Collector Configuration; Clipper and Clamper, Rectifiers, Basics of MOSFET.</p>

7	Contents for lab	Familiarization with CRO, DSO and Electronic Components, Diodes characteristics - Input-Output and Switching, BJT and MOSFET Characteristics, Zener diode as voltage regulator, Rectifiers, Clippers and Clampers, Network laws and theorems, Measurement of R,L,C parameters, A.C. series and parallel circuits, Measurement of power in 3 phase circuits, Reactance calculation of variable reactance choke coil, open circuit and short circuit tests on single phase transformer, Starting of rotating machines.
8	Text /references	<ul style="list-style-type: none"> • Electronic Devices and Circuit Theory by R.L. Boylestad and L. Nasheisky, Pearson. • Basic Electrical Engineering by J. Nagrath and D. P. Kothari, TATA Mc Graw Hill. • Electric Circuits by D. A. Bell, Oxford Higher Education. • Modern Semiconductor Device Physics by S.M. Sze, Wiley. • Electrical Technology by E. Hughes, Pearson Education. • Electrical Engg Fundamentals by V. Del Toro, PHI Learning. • Electronic Devices and Circuits by Milliman, J. and Halkias, C.C., Tata McGraw Hill. • Introduction to Electrical Engineering by Naidu, M.S. and Kamashaiah, S., Tata McGraw Hill.

1	Code of the subject	ES101
2	Title of the subject	Engineering Physics
3	Prerequisite	Basic knowledge of fundamentals of physics
4	L-T-P	3-0-2
5	Learning Objectives	Engineering Physics offers a multidisciplinary undergraduate program spanning engineering and physics in which fundamental physical principles are used to address research problems of technological importance at the frontiers of engineering and science. It promotes the understanding of the physical environment while discovering how physics is applied to problem-solving in our changing high-tech world. The engineering physics curriculum is designed to fulfill the educational requirements for professional work in various fields of applied science which are based upon a thorough knowledge of physics and foundation of basic scientific principles as well as the theoretical knowledge and skills required for specific engineering applications. Engineering physicists perform research and development in various industries pertaining to fields of telecommunications, microelectronics, lasers, fiber optics, nanotechnology and quantum computers.

6	Brief Contents	<p>Quantum Physics: Black body radiation, Planck's hypothesis, wave particle duality, de-Broglie Hypothesis, Heisenberg uncertainty principle, photoelectric effect, Compton effect, phase and group velocity, wave function & its physical significance, Schrodinger's wave equation, Applications of Schrodinger equation.</p> <p>Electrodynamics: Maxwell's equations: differential and integral forms, significance of Maxwell's equations, displacement current and correction in Ampere's law, electromagnetic wave propagation, transverse nature of EM waves, applications, pointing vector & Poynting theorem.</p> <p>Physics of Materials: Types of Solids, Miller indices, Crystal structure, crystal systems, energy bands in solids, classification of solids, conductivity in metals and concepts of Fermi level, effective mass and holes, phonons, bulk and nanomaterials. Synthesis and characterization techniques, Graphene and 2D materials and its applications.</p> <p>Laser and Fiber Optics: Principles of lasers, Einstein Coefficients and their relations, Types of Lasers and their applications. Concept of optical fibers and types of optical fibers, modes of propagation, fiber optic communication, optical fiber sensors, connector and couplers.</p>
8	Contents for lab	Practical experiments based on theory contents.
9	Text /references	<ul style="list-style-type: none"> • Engg. Physics- Kakani & Kakani, CBS Publications. • David J Griffith, <i>Introduction to Quantum Mechanics</i>, 2nd ed. , PHI, 2013. (Text Book). • Avadhanulu, M. N, & Kshirsagar, S. G., <i>A Textbook of Engineering Physics</i>, S. Chand, 2014. (Text Book) • Neeraj Mehta, <i>Applied Physics for Engineers</i>, PHI Learning Pvt. Ltd., 2011. (Text Book) • Fiber optic communication- J Keiser (McGraw Hill) (Text Book) • David J Griffith, <i>Introduction to Electrodynamics</i>, 4th ed. , PHI, 2014. (Ref.). • Paul Dirac, <i>Principles of Quantum Mechanics</i>, 4th ed., Oxford Uni. Press, 2004. (Ref.) • Kittel, C., <i>Introduction to Solid State Physics</i>, 8th ed., Wiley, 2014. (Ref.) • Malik and Singh, Engg Physics, TMH

1	Code of the subject	ES102
2	Title of the subject	Engineering Mathematics
3	Any prerequisite	None
4	L-T-P	3-1-0

5	Learning Objectives	<ul style="list-style-type: none"> To explore the connections of mathematical foundation courses (Algebra, Calculus and Differential Equations) to the mathematics in the later engineering subjects. To provide platform for the exchange of ideas, practices and pedagogy in the mathematics education in engineering and technical institutions.
6	Brief Contents	<p>Vector spaces over arbitrary field, subspaces, linear combination, spanning set, linear dependence and independence of vectors, basis and dimension of vector spaces. Linear Transformation, The Null Space and the Range Space of a Linear Transformation, Rank, Nullity, Rank-Nullity Theorem, Algebra of linear transformations, Isomorphism, Matrix representation, Linear functionals, Annihilator, Transpose of a linear transformation. Matrix representation, matrix representation of a linear transformation, Rank of a matrix - echelon form, normal form, types of matrices-symmetric, skew-symmetric, Hermitian, skew-Hermitian, orthogonal, unitary matrices, consistency of system of linear equations (Homogeneous and Non-Homogeneous). Eigen values and Eigen vectors and their properties (Hermitian, Skew-Hermitian, Unitary matrices), Characteristic equations, Cayley-Hamilton theorem (without proof), Diagonalisation, Inner product, Norms of vectors, orthogonal vectors, Cauchy Schwarz Inequality, Triangle inequality. Introduction of function of two variables, Limit, Continuity, Partial differentiation, Differentiations, Maxima and minima for a function of several variables, Method of Lagrange multipliers with one subsidiary condition, Applications of maxima and minima with illustrative examples, Jacobians- Simple problems.</p>
7	Contents for lab	Not applicable
8	Text /references	<ol style="list-style-type: none"> 1. Linear Algebra and its Applications, <u>Gilbert Strang</u>. 2. Fundamentals of Linear Algebra, James B. Carrell 3. Functions of Several Variables, Wendell Fleming

1	Code of the subject	EE102
2	Title of the subject	Engineering Design Principles
3	Any prerequisite	None
4	L-T-P	2-0-2
5	Learning Objectives	The course should enable the students to:

		<ul style="list-style-type: none"> • Widen students' knowledge on design process. • Enable Students to attain knowledge on tools used in Design Methods. • Create an understanding on the process of material selection and design. • Develop in depth knowledge on Engineering statistics and reliability. • Create awareness on legal and ethical issues in Design an Quality Engineering.
6	Brief Contents	<p>Design process, Morphology of Design, Design Drawings, Computer Aided Engineering, Designing of, Product life cycle, Human Factors in Design, Industrial Design.</p> <p>Design Methods, Creativity and Problem Solving, Product Design Specifications, Conceptual design, Embodiment Design, Finite Element Modeling, Optimization, Search Methods, Material Selection Processing and Design, Engineering Statistics and Reliability, Legal and Ethical Issues in Design and Quality Engineering</p>
7	Contents for lab	<p>Create geometric constructions; drawing parallel and perpendicular lines, and to construct circles, arcs, tangencies, and irregular curves, Apply orthographic projection method to obtain: Multiview , auxiliary view and section view of an object, Create 2-D computer drawing, Create 3-D computer drawing : using Computer Aided Design (CAD) software</p>
8	Text /references	<ul style="list-style-type: none"> • Fundamentals of Engineering Drawing by W.J. Luzadder and J.M. Duff, PHI. • Engineering Design - "A Materials and Processing Approach" by Dieter, George E., McGraw Hill. • Product Design and Development by Karl T. Ulrich and Steven D. Eppinger, McGraw Hill. • Engineering Design by Pahl, G, and Beitz, W., Springer – Verlag, NY. • Elements of Engg. Design by Ray, M.S., Prentice Hall Inc. • The principles of Design by Suh, N. P., Oxford University Press, NY. • Visualization, Modeling, and Graphics for Engineering Design by D.K. Lieu and S.A. Sor, Cengage Learning. • Fundamentals of Computer Graphics by Shirley, Peter, Michael Ashikhmin, Steve Marschner, CRC Press.

1	Code of the subject	CS101
2	Title of the subject	Principles of Computer Programming
3	Prerequisite	No

4	L-T-P	3-0-2
5	Learning Objectives	To understand the basic principles of programming languages. To provide design & development of C and Python programming skills. To introduce problem solving methods and program development.
6	Brief Contents	Basics of Computer Languages C, Compilers, Interpreter, Programming Environments and Debugging: types of errors and debugging techniques. Programming features: Data types, Expressions and Operators, Control statements, Iterations. Functions: Scope of variables, call by value, call by reference, Recursion, Pointers. Array, String, Structures and Unions. File handling, File redirection, File pointers. Applications of C programming concepts in different data structures. Python: Introduction, Program Organization, Functions, Modules and Libraries.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text/references	<ol style="list-style-type: none"> 1. Kernighan, B.W. and D. M. Ritchie (1998): The C programming language, 2nd ed. Prentice Hall of India. 2. Kanetkar, Y (2016): Let us C, 15th ed .BPB Publications. 3. King K.N (2008): C Programming: A Modern Approach. 2nd ed. W. W. Norton & Company.

1	Code of the subject	CS102
2	Title of the subject	Data Structures
3	Prerequisite	Principles of Computer Programming
4	L-T-P	3-0-2
5	Learning Objectives	To understand the basic data structures and algorithms for performing operations on data structures, the use of data structures to provide efficient software solutions, and some algorithm paradigms for building efficient algorithms.
6	Brief Contents	Introduction to Abstract data types, linear and linked data structures – Arrays, Stacks, Queues, Linked List. Introduction to searching and sorting algorithms –Quick sort, Merge sort, Heap sort, linear time sorting; evaluation of infix/postfix expressions. Trees, binary search trees and basic operations, AVL trees, heaps, hash tables. Algorithm analysis: time and space complexity,

		asymptotic behavior, estimating runtime, comparison of algorithms. Graphs and basic algorithms on graphs: depth first and breadth first search, Dijkstra's algorithm. Hash Tables
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text/references	1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. 2009. Introduction to Algorithms, Third Edition (3rd ed.). The MIT Press. 2. Steven S. Skiena. 2008. The Algorithm Design Manual (2nd ed.). Springer Publishing Company, Incorporated.

1	Code of the subject	HS 101
2	Title of the subject	Freshman Skills
3	Any prerequisite	No
4	L-T-P	2-0-0
5	Learning Objectives	To improve their Personal Skills and Attributes, Study Skills and academic preparation, and learn Community Service.
6	Brief Contents	<p>Personal Skills and Attributes Focus: Self-Awareness, Self-Management, and Character Development, Institute personnel and available services, the rotating schedule, acceptable use of social media, opportunities for involvement in extracurricular clubs and sports, effective time-management skills, positive character traits, building self-awareness.</p> <p>Study Skills and Academic Preparation Focus: The Principles of Learning, Establishing Strong Study Skills, Developing an Academic , Pathways, Personal Goals, identify personal post-secondary goals, inherent aptitudes, exploring post-secondary options, academic requirements for future goals, financial requirements for future goals, local and global economics, societal trends, cultural trends, Possible linguistic needs, transferable skills, resume foundations</p>
7	Text /references	

1	Code of the subject	EE104
2	Title of the subject	Hardware Workshop
3	Prerequisite	NA
4	L-T-P	1-0-4
5	Learning Objectives	<ul style="list-style-type: none"> To familiarize students with various electronic devices and their specifications. Develop skill for Design and testing of different types of electronic subsystems using Analog and Digital IC's Familiarize students with PCB layout tool to prepare PCB print for assigned projects. Develop skills of writing a structured technical document for project and its presentation. Develop the ability to diagnose faults and their rectification.
6	Brief Contents	<ul style="list-style-type: none"> Familiarization /Identification of electronic components with specification and Functionality, type, size, colour coding, package, symbol, cost etc. Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Switches, Relays, Crystals, Displays, Fasteners, Heat sink, Arduino Uno, Rasberry Pi, ESP8266 Module, HC 05 Bluetooth Module. Drawing of electronic circuit diagrams using EDA tools, Interpret data sheets of discrete components and IC's, Estimation and costing, Familiarization/Application of testing instruments and commonly used tools like Multimeter, Function generator, Power supply, CRO etc. Soldering iron, De-soldering pump, Cutters, Wire strippers, Screw drivers, Hot air soldering and desoldering station etc., Testing of electronic components Resistor, Capacitor, Diode, Transistor etc. using multimeter and different IC's using IC tester, Design and fabrication of a single sided PCB for a simple circuit with manual etching, Assembling electronic circuit/system on general purpose PCB, testing and show the functioning
7	Contents for lab	Hardware Based Projects for smart city applications, industries, healthcare, education, agriculture, transportation, power, including social development sector etc.
8	Text /references	https://electronicsforu.com/ https://electronicsforu.com/tag/mini-projects . Electronics Lab Manual by K. A. Navas, PHI. Electronic Projects in Workshop by R.A Penfold, Newnes Technical Books. Electronic Designer's Handbook by T.K. Hamingway, Business Books Limited. Digital Circuits and Logic Design by S. Lee, Prentice Hall India. Digital Principles and Applications by D. P. Leach, A. P. Malvino and G. Saha, McGraw Hill Education. Digital Design by M. M. Mano and M.D. Ciletti, Pearson, Prentice Hall.

1	Code of the subject	<ul style="list-style-type: none"> HS102
2	Title of the subject	<ul style="list-style-type: none"> Sports and Physical Education
3	Prerequisite	<ul style="list-style-type: none"> No
4	L-T-P	<ul style="list-style-type: none"> 0-1-2

5	Learning Objectives	<ul style="list-style-type: none"> • Students will get knowledge and understanding of the facts, concepts and practice relating to a range of sports-both indoor and outdoor. • To teach the students how to keep them fit, to increase his/her concentration, team coordination ability, which will help them as a professional.
6	Brief Contents	<ul style="list-style-type: none"> • he course will be taught in two components • Theory, Sport History, Human Anatomy, Stress Management/ Meditation/Yoga, Important tournaments and its players, Rules and Field Requirements, Sport Equipment, Sports Psychology, Role of IT in sports
7	Contents for Field Sessions	<ul style="list-style-type: none"> • Indoor/ Outdoor: Cricket/ Football/ Volleyball/ Basketball/Badminton/ Table-Tennis/ Lawn-Tennis/ Athletics/ Yoga
8	Text/references	<ul style="list-style-type: none"> • Nation at Play: Ronojoy Sen • The Art of Captaincy: What Sports teaches us about Leadership by Mike Brearley • The Anatomy of Exercise and Movement for the Study of Dance, Pilates, Sports, and Yoga by Jo Ann Staugaard-Jones • Stress and Its Management by Yoga, by K.N. Udupa, R.C. Prasad • THE WINNING WAY: Learning from Sport for Managers by Anita Bhogle, Harsha Bhogle • Think Like a Champion by Webster, Rudi V. • Attitude is Everything, by Jeff Keller

1	Code of the subject	CS103
2	Title of the subject	Object Oriented Programming
3	Prerequisite	Programming concepts
4	L-T-P	3-0-2
5	Learning Objectives	To develop programming skill and to solve engineering related problems using Object Oriented Programming Concepts.
6	Brief Contents	Object oriented thinking: Need for OOP Paradigm, Procedural programming vs object oriented programming, object oriented concepts. Class and object concepts: Difference between C structure and class, specifying a class, Defining members inside and outside class, etc. Constructor and destructor concepts, Operator overloading and Type Conversion, Inheritance and polymorphism concepts Working with files: Classes for file stream operations, opening and closing files, File opening modes, file Pointers, Error handling during file operations, command line arguments. Templates: Class template, class template with parameter, function template, function template with parameter and Exception handling
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	List of text books/references	1. HM Deitel and PJ Deitel —C++ How to Program, Seventh Edition, 2010, Prentice Hall. 2. Brian W. Kernighan and Dennis M. Ritchie, —The C programming Language, 2006, Prentice-Hall. 3. E Balagurusamy, —Object oriented Programming with C++, Third edition, 2006, Tata McGraw Hill. 4. Bjarne Stroustrup, —The C++ Programming language, Third edition, Pearson Education. 5. Horstmann —Computing Concepts with C++ Essentials, Third Edition, 2003, John Wiley. 6. Robert Lafore, —Object Oriented Programming in C++, 2002, Pearson education.

	Code of the subject	HS103
	Title of the subject	Ecology and Environment Sciences
	Prerequisite	No
	L-T-P	2-0-0

	Learning Objectives	<p>Upon course completion, students will be able to:</p> <ol style="list-style-type: none"> 1. Understand the basic principles of ecology and ecosystem function. 2. Describe the interrelationships between land, sea, the atmosphere, and the living things that occupy these environments. 3. Determine the role that humans play in affecting the characteristics of the environment. 4. Evaluate current environmental issues and problems including the solutions and management practices that have been used or offered to address these issues and problems.
	Brief Contents	<p>Environment and Human Intervention Environment: Definition, environment and ecology, importance of environment, need of public awareness, sustainable ecosystem, human activities, and environment-agriculture, transport, mining, Environmental Impact Assessment (EIA)</p> <p>Environmental Pollution Water pollution, waste-water treatment- case studies, land pollution, air pollution, noise pollution, Pollution and public health issues, pollution and environment, greenhouse effect</p> <p>Environment Protection Policies Environment policies, forests, biosphere reserves, flora and wildlife, environment laws/acts, environmental movements, environment ethics and awareness, role of government and non-government organizations, introduction to GST-CGST and SGST, Swachh Bharat Abhiyan- initiatives, responsibilities and future aspects, Cash-less economy-modes of payment-money transfer (advantages and disadvantages), Making in India concept.</p> <p>Applied issues in Ecology Sustainability, habitant degradation, degradation of urban and industrial landscape, conservation, threats to biodiversity, evolutionary ecology</p>
	Contents for lab	NA
	Text /references	<ol style="list-style-type: none"> 1. Townsend, C.R., Begon, M. and Harper, J.L., 2003. <i>Essentials of ecology</i> (Ed. 2). Blackwell Science. 2. R. Rajagopalan, 2011. <i>Environmental Studies</i>, Oxford IBH Pub. 3. Martell, L., 2013. <i>Ecology and Society: An introduction</i>. John Wiley & Sons.

1	Code of the subject	CS104
2	Title of the subject	Mobile Application Technologies
3	Prerequisite	No
4	L-T-P	0-1-2
5	Learning Objectives	To develop the basic skills of using Android IDE and Android SDK for implementing Android applications
6	Brief Contents	Introduction, UX development, Testing and debugging of front end and back end application components and their interaction.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	1. Android Programming: The Big Nerd Ranch Guide 4th Edition, Bill Phillips, Brian Hardy 2. The Busy Coder's Guide to Android Development, Mark Murphy.

1	Code of the subject	EE103
2	Title of the subject	Digital Electronics
3	Prerequisite	NA
4	L-T-P	3-0-2
5	Learning Objectives	After the completion of the course, the students will be able to: <ul style="list-style-type: none"> • Recognize and apply the number systems and Boolean algebra. • Reduce Boolean expressions and implement them with Logic Gates. • Analyze, design and implement combinational and sequential circuits
6	Brief Contents	Boolean algebra, K-maps, logic gates, Number Systems, Design of combinational circuits, Design of sequential circuits, Introduction to digital logic families, Data processing and conversion: Sample and hold circuits, ADCs and DACs; Basic memory circuits ROM, RAM and PLA.
7	Contents for lab	Implementation of digital logic using switching circuits, Study of universal gates, Design of a 1-bit Full Adder/Subtractor using logic gates, Design and implementation of a 4-bit binary ripple, adder using logic gates, 4 X 3 bit binary multiplier using logic gates, Study of code converters (BCD to excess-3, binary to gray and gray to binary), Study of combinational MSI circuits – 1-bit half/full, adder, 1-bit half/full subtractor and 1-bit magnitude, comparator, Study of sequential circuits – Implementation of Flip-Flops, Design of a synchronous

		decade counter, Design of 4-bit parallel input serial output (PISO), shift-register.
8	Text /references	<ul style="list-style-type: none"> • Digital Circuits and Logic Design by S. Lee, Prentice Hall India. • Digital Principles and Applications by D. P. Leach, A. P. Malvino and G. Saha, McGraw Hill Education. • Digital Design by M. M. Mano and M.D. Ciletti, Pearson, Prentice Hall. • Digital Principles and Design by Donald D Givone, McGraw-Hill. • Digital Design: Principles and Practices by John F Wakerly, Pearson. • Digital Electronics: Principles Design and Applications by AK Maini. • Digital Integrated Electronics by H. Taub and D. Schilling, McGraw Hill.

1	Code of the subject	ES103
2	Title of the subject	Probability and Statistics
3	Prerequisite	NIL
4	L-T-P	3-1-0
5	Learning Objectives	To introduce students about basics of probability theory and statistics.
6	Brief Contents	<p>Introduction: Measures of Central Tendency, Measures of Dispersion, Measures of Skewness, and Measures of Kurtosis, Moments about mean and about any point.</p> <p>Probability: Basic terminology, Types of Probability, Probability rules, Bayes Theorem, Probability distribution, Binomial, Poisson, Negative-Binomial, Geometric, Hyper-geometric, Uniform, Exponential, Normal distribution, log-normal, beta and gamma distributions.</p> <p>Sampling: Types and Sampling Distribution, Random sampling, Relationship between sample size and standard error, Central limit theorem, Weak law of large numbers, estimation theory (MLE).</p> <p>Testing Hypotheses-1: One Sample Tests, Basics to hypotheses, Inference of single mean/proportion, Measuring the power of hypotheses test (z-test and t-test), P-values, interval estimation.</p> <p>Testing Hypotheses-2: Two Sample Tests, Testing for differences between means/proportions.</p> <p>Testing Hypotheses-3: Chi-Square distribution, Chi-Square as a test of independence, Testing the appropriateness of a distribution, Analysis of variance (ANOVA), Inference about a population variance (Chi-square test, F-test).</p> <p>Nonparametric tests (Self Study): The sign-test, Rank-sum, test of randomness, Kolmogorov-Smirnov, Anderson-Darling test.</p> <p>Simple Regression and Correlation: Estimation using the regression line, Correlation analysis, making inferences about population parameters.</p> <p>Multiple Regression: Multiple regression and correlation analysis, Finding multiple regression equation, Inferences about population parameters.</p>

7	Contents for lab	NA
8	Text /references	<ol style="list-style-type: none"> 1. Johnson, R. A., Miller & Freund's Probability and statistics for engineers, Pearson Education, 2000. 2. Ross S. M., Introduction to Probability and Statistics for Engineers and Scientists 5th Edition, Elsevier. 3. Hogg R. V., Craig A., Probability and Statistical Inference, 6th edition, Pearson Education.

1	Code of the subject	HS201
2	Title of the subject	Indian culture, Ethics and Morale
3	Prerequisite	No
4	L-T-P	2-0-0
5	Learning Objectives	<p>Upon course completion, students will be able to:</p> <ol style="list-style-type: none"> 1. Identify and analyze an ethical issue in the subject matter under investigation or in a relevant field. 2. Articulate what makes a particular course of action ethically defensible. 3. Assess their own ethical values and the social context of problems. 4. Evaluate the concept of karma that helps to maintain work life balance. 5. Demonstrate contemporary approaches to leadership who inspires human being to reach their goals
6	Brief Contents	<p>Human Values and Ethics Morals, values and ethics-integrity, work ethics, service learning, civic virtue, respect for others, living peacefully, caring, sharing, honesty, courage, cooperation, commitment, empathy, self-confidence, character, spirituality.</p> <p>Work Ethos and Values Meaning of work ethos, levels, dimensions, steps, factors responsible for poor work ethos. Meaning of values, features, values for Indian managers, relevance of value-based management in global change, impact of values on stakeholders: employees, customers, government, competitors and society, values for managers, trans-cultural human values in management and management education, secular v/s spiritual values in management, importance of value system in work culture</p> <p>Indian Ethos-An Overview Meaning, features, need, history, relevance, principles practised by Indian companies, requisites, elements, role of Indian ethos in managerial practices, management lessons from Vedas, Mahabharata, Bible and Quran.</p> <p>Contemporary Approaches to Indian Ethos</p>

		Contemporary approaches to leadership, joint Hindu family business, leadership qualities of karta, Indian systems of learning - gurukul system of learning, advantages- disadvantages of karma, importance of karma to managers, nish kama karma, laws of karma, law of creation, law of humility, law of growth, law of responsibility, law of connection, corporate karma leadership.
7	Contents for lab	NA
8	Text /references	<ol style="list-style-type: none"> 1. Khandelwal, N. M., 2011. <i>Indian Ethos and Value for Management</i>. Himalaya Publishing House, 1st Edition. 2. Govindarajan, M., Natarajanad, S., SenthilKumar V.S., 2009. <i>Engineering Ethics includes Human Values</i>. PHI Learning Pvt. Ltd. 3. Nandagopal R., Ajith Rn., 2010. <i>Indian Ethos and Values in Management</i>. Tata McGraw Hill Education, 1st Edition. 4. Murthy, P.S.R., 2013. <i>Indian Culture, Values and Professional Ethics</i>. BS Publication

1	Code of the subject	CS201
2	Title of the subject	Discrete Structures
3	Prerequisite	Engineering Mathematics
4	L-T-P	3-1-0
5	Learning Objectives	To prepare for a background in abstraction, notation, and critical thinking for the mathematics most directly related to computer science. To foster rigorous thinking skills that can enhance the quality of work of computing professionals. To relate and apply these concepts to practical applications of computer science.
6	Brief Contents	Fundamentals of Logic and their use in program proving, resolution principle. Set Theory and Functions, Graph Theory, Group Theory, Elementary Combinatorics etc.
7	Text/references	<ol style="list-style-type: none"> 1. Bernard Kolman, Robert C Busby, S. Ross, Discrete Mathematical Structures, PHI Learning 2. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill Edition 3. I.N. Herstein, Topics in Algebra, John Wiley Publications 4. Ralph P. Grimaldi, B.V. Ramana, Discrete and Combinatorial Mathematics, Pearson Education

1	Code of the subject	CS202
2	Title of the subject	Computer Organisation and Architecture
3	Any prerequisite	Digital Electronics, Principles of computer programming
4	L-T-P	3-0-2

5	Learning Objectives	To understand the Organization and architecture aspects of computer followed by the Application Binary Interfaces.
6	Brief Contents	Basic functional blocks of a computer, introduction to Instruction set architecture of a CPU and instruction sets of some common CPUs. Data representation, Computer arithmetic, Control unit design, Memory system, Peripheral devices and their characteristics, Performance enhancement techniques Pipelining, Memory organization.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text/references	1. Computer Organization and Design: The Hardware/Software Interface, David A Patterson, John L. Hennessy, 4th Edition, Morgan Kaufmann. 2. Computer Architecture and Organization by William Stallings, PHI Pvt. Ltd., Eastern Economy Edition.

1	Code of the subject	CS203
2	Title of the subject	Design and Analysis of Algorithms
3	Prerequisite	Data Structures, Principles of Computer Programming, Engineering Mathematics
4	L-T-P	3-0-2
5	Learning Objectives	To understand the performance aspects of algorithms in programming the computing systems
6	Brief Contents	Introduction, Asymptotic complexity, Searching in list, Concepts of graphs and shortest path estimation algorithms, Divide and conquer approaches, Search Trees, Greedy : Interval scheduling, Greedy :Proof strategies,Greedy : Human coding, Dynamic Programming: weighted interval scheduling Dynamic Programming, Intractability: NP completeness, Intractability :reductions and examples
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text/references	1. Introduction to Algorithms (Eastern Economy Edition) by Thomas H Cormen and Charles E Leiserson. 2. Design and Analysis of Algorithms by S Sridhar. 3. Design and Analysis of Computer Algorithms by AHO.

1	Code of the subject	CS204
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2	Title of the subject	Database Systems
3	Prerequisite	
4	L-T-P	3-0-2
5	Learning Objectives	To understand a Database application, the design and performance aspects from the perspective of Database systems of the past, present and future.
6	Brief Contents	Introduction to Databases, Relational Data Model, Relational Algebra, SQL and NoSQL concepts, Database Normalization, Indexing, Database Transactions, Recovery Systems, Transaction Schedules, Concurrency Control, Query Processing and Query Optimization.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	<ol style="list-style-type: none"> 1. Abraham Silberschatz, Henry Korth, and S. Sudarshan. Database Systems Concepts (5ed.). McGraw-Hill, New York, USA. 2. Ramez A. Elmasri, Shankrant B. Navathe. Fundamentals of Database Systems Addison-Wesley Longman Publishing Co. 3. Paul DuBois. Mysql. New Riders Publishing 4. C. J. Date. Database in Depth: Relational Theory for Practitioners. O'Reilly Media, Inc. 5. Bipin C. Desai. An Introduction to Database Systems. West Publishing Co.

1	Code of the subject	CS205
2	Title of the subject	Paradigms of Programming Languages
3	Prerequisite	Principles of Computer Programming, Object Oriented Programming
4	L-T-P	3-0-2
5	Learning Objectives	To understand the key principles of programming language paradigms, compare and contrast the advantages and disadvantages of the imperative and functional programming paradigms, describe the compilation principles and highlight modern trends' impact on programming languages.

6	Brief Contents	The role and for programming languages, characteristics; Programming language paradigms, Language design and translation issues; Properties of data types and objects, type conversion, binding and binding times. Procedures Sequence Control, Subprogram control, desirable and undesirable characteristics of procedural programming. Case study of Pascal. Functional Programming Paradigm, Declarative Programming Paradigm, Parallel Programming Paradigm, Classification of computer architectures, principles of parallel programming, precedence graph, data parallelism, control parallelism, message passing, shared address space, synchronization mechanisms, mapping, granularity, compilers, operating systems; Additional Programming Paradigms Data flow programming design principles, Database programming design principles, Network programming design principles, Socket programming in JAVA, Internet programming design principles etc.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text/references	<ol style="list-style-type: none"> 1. RoostaSeyed, "Foundations of Programming Languages Design & Implementation", Cenage learning. 2. Pratt T.W., Zelkowitz "Programming Languages: Design and Implementation" PHI 3. Programming Language Design Concepts, D. A. Watt, Wiley India Edition. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. Sebesta R. W., "Concepts of programming languages", Pearson Education 2001, 4th edition. 2. Sethi Ravi, "Programming Languages: Concepts and Constructs" Pearson Education, 3. Herbert Schildt "The Complete Reference Java2", 5th edition, Tata McGraw Hill.
1	Code of the subject	MS619
2	Title of the subject	Entrepreneurship and Innovation
3	Prerequisite	No
4	L-T-P	2-0-0
5	Learning Objectives	Course is designed for preparing students to take of Entrepreneurial journey on the basis of innovative ideas. The content is highly focused to start venture to making business mature up-to international level.
6	Brief Contents	Entrepreneurship, Creativity and innovation, Business planning process, Institutions supporting entrepreneurs, Family businesses, International entrepreneurship opportunities, Informal risk capital and venture capital, Managing growth.

7	Contents for lab	No
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1	Code of the subject	CS206
2	Title of the subject	Theory of Computation
3	Prerequisite	No
4	L-T-P	3-0-0
5	Learning Objectives	To introduce the mathematical foundations of computation, develop the ability to understand and conduct mathematical proofs for computation and algorithms.
6	Brief Contents	Finite Automata, Finite State system concepts, Regular Languages, Equivalence of NFA and DFA, Minimization of DFA- – Pumping Lemma for Regular. Grammars, Pushdown Automata, Turing Machines, Unsolvability Problems and Computable functions, Measuring and classifying complexity: Tractable and Intractable problems- Tractable and possibly intractable problems – P and NP completeness – Polynomial time reductions.
7	Text /references	<p>1. Hopcroft J.E., Motwani R. and Ullman J.D, —Introduction to Automata Theory, Languages and Computations, Pearson Education.</p> <p>2. John C Martin, —Introduction to Languages and the Theory of Computation, TMH, New Delhi.</p> <p>REFERENCES</p> <p>1.Mishra K L P and Chandrasekaran N, —Theory of Computer Science – Automata, Languages and Computation, Third Edition, Prentice Hall of India</p> <p>2.Harry R Lewis and Christos H Papadimitriou, —Elements of the Theory of Computation, Second Edition, Prentice Hall of India, Pearson Education, New Delhi.</p> <p>3.Peter Linz, —An Introduction to Formal Language and Automata, Third Edition, Narosa Publishers.</p> <p>4.KamalaKrithivasan and Rama. R, —Introduction to Formal Languages, Automata Theory and Computation, Pearson Education.</p>

1	Code of the subject	CS207
2	Title of the subject	Operating Systems
3	Prerequisite	Computer Organization; Data Structures and Computer Programming
4	L-T-P	3-0-2
5	Learning Objectives	To study the importance of the operating system and its function, techniques of the operating system to achieve its goals as resource manager. Application interaction with the operating system and the operating systems interaction with the machine.
6	Brief Contents	Introduction and history of Operating systems, Process concepts and scheduling, Storage management, Processor management, Interprocess communication, CPU scheduling, Process Synchronization, Memory Management, Virtual memory concepts, Deadlocks, Device management, File management, File Systems, Free space Management: Bit vector, Linked list. Some case Studies of traditional and modern operating systems.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	<ol style="list-style-type: none"> 1. A. Silberschatz & P.B. Galvin, Operating System concepts and principles, Wiley India. 2. A. Tanenbaum, Modern Operating Systems', Prentice Hall India 3. W. Stallings, _Operating Systems: Internals and design Principles, Pearson Ed. 4. M.J. Bach, Design of Unix Operating system', Prentice Hall. <p>Additional Reading:</p> <ol style="list-style-type: none"> 1. D.M. Dhamdere, Operating Systems: a concept based approach', Tata McGraw-Hill Pubs. 2. G. Glass, Unix for programmers and users-a complete guide, Pearson Ed.

1	Code of the subject	CS208
2	Title of the subject	Computer Networks
3	Prerequisite	User applications and some aspects of process and their interaction
4	L-T-P	3-0-2
5	Learning Objectives	The understand the purpose and overview of the Internetworking technology, issues, and approaches using top-down philosophy.
6	Brief Contents	Computer Networks and the Internet, Network Application Architectures, Processes Communication, Transport Services, Application-Layer Protocols, The Web and HTTP, Case Study: P2P Internet Telephony with Skype, Socket Programming with TCP and UDP; Transport Layer: Relationship Between Transport and Network Layers, Overview of the Transport Layer in the Internet, Principles of Reliable Data Transfer Services, Multiple Access protocols, Link-Layer concepts; Wireless and Mobile Networks, Cellular Internet Access, Mobile IP.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	Computer Networking: A top-down approach featuring the Internet / James F. Kurose , Keith W. Ross., 7th edition, Pearson.

1	Code of the subject	CS209
2	Title of the subject	Mathematical Foundations of Computing
3	Prerequisite	Nil
4	L-T-P	3-1-0
5	Learning Objectives	To model computer science domain problems mathematically, think abstractly and employ techniques to study the properties.
6	Brief Contents	Induction, Propositional predicate logic, First order logic, Proof techniques and applications, Linear programming, Series divergence/convergence, Fourier Series/Transform, number theory etc.
7	Text /references	<ol style="list-style-type: none"> 1. Donald F. Stanat and David F. McAllister, Discrete mathematics in Computer Science. 2. Thomas Koshy, Elementary number theory with Applications, Elsevier 3. I. N. Herstein, Topics in Algebra. JOHN Wiley & SONS. 1990. 4. Simulyan, First Order Logic

1	Code of the subject	CS210
2	Title of the subject	Software Engineering
3	Prerequisite	
4	L-T-P	3-0-2
5	Learning Objectives	To impart software engineering concepts helpful for designing software systems for standalone and networked applications.
6	Brief Contents	Introduction, Software development process, project management process. Software requirement Analysis and specification; Software planning, Software design, Verification and validation techniques, Software quality and reliability, System Reliability and Reliability measures
7	Contents for lab	Use of software design tools (UML etc.) for design, software applications design and testing on various application centric measures, Fintech software design etc.
8	Text /references	1. Pham, Hoang. System software reliability. Springer Science & Business Media, 2007. 2. Jalote Pankaj, An Integrated Approach to Software Engineering, Narosa Publishing House 3. Pressman, Roger S., Software Engineering : A practitioner's Approach, McGraw-Hill, Inc.

1	Code of the subject	MS603
2	Title of the subject	Business Economics
3	Any prerequisite	No
4	L-T-P	3-0-0
5	Learning Objectives	To equip students with the necessary theory and techniques and the ability to apply them in order to inform and enhance managerial decision making.
6	Brief Contents	Introduction to Economics; Nature and Scope of Management Economics, Significance in decision-making and fundamental concepts, Consumer behaviour and typical characteristics of Indian consumer, Consumer decision making process, Indian market: characteristics, Objectives of a firm, Demand Analysis, Law of Demand, Exceptions to the law of Demand, Determinants of Demand. Elasticity of Demand- Price, Income, Cross and Advertising Elasticity, Uses of Elasticity of Demand for managerial decision making, Measurement of Elasticity of Demand, Demand forecasting meaning, significance and methods, Supply Analysis, Law of Supply, Supply Elasticity, Analysis and its uses for managerial decision making, Production concepts & analysis, Production function, single

		variable-law of variable proportion, two variable-Law of returns to scale, Cost concept and analysis, short-run and long-run cost curves and its managerial use, Market Equilibrium and Average Revenue Concept, Market Structure: Perfect Competition, features, determination of price under perfect competition, Monopoly: Feature, pricing under monopoly, Price discrimination, Monopolistic: Features, pricing under monopolistic competition, product differentiation, Oligopoly: Features, kinked demand curve, cartels, price leadership, Pricing strategies Price determination, Full cost pricing, Product line pricing, Price skimming, Penetration pricing, National Income; Concepts and various methods of its measurement, Inflation, types and causes, Business cycle, Profit concept and major theories of profits; Dynamic Surplus theory, Risk & Uncertainty bearing theory and Innovation theory
7	Contents for lab	No

1	Code of the subject	CS301
2	Title of the subject	Compiler Design
3	Prerequisite	Theory of Computation
4	L-T-P	3-0-2
5	Learning Objectives	To design the front end of the compiler, scanner, parser, intermediate code generator, objectcode generator, and the parallel compilation strategies. To gain the ability to implement a parser etc.
6	Brief Contents	The structure of Compiler – Lexical analysis, Syntax analysis, LR parsers; Intermediate code generation concepts, Object code generation, Code optimization, Parallelizing compiler etc.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	<ol style="list-style-type: none"> 1. Alfred V. Aho, Monica S.Lam, Ravi Sethi, Jeffrey D.Ullman, Compilers : Principles, Techniques and Tools, Second Edition, Pearson Education. 2. Randy Allen, Ken Kennedy, Optimizing Compilers for Modern Architectures: A Dependence-based Approach, Morgan Kaufmann Publishers. 3. Steven S. Muchnick, Advanced Compiler Design and Implementation , Morgan Kaufmann Publishers - Elsevier Science, India, Indian Reprint.

		4. Keith D Cooper and Linda Torczon, Engineering a Compiler, Morgan Kaufmann Publishers Elsevier Science. 5. V. Raghavan, Principles of Compiler Design, Tata McGrawHill Education Publishers.
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1	Code of the subject	CS302
2	Title of the subject	Computer Graphics
3	Prerequisite	
4	L-T-P	3-0-2
5	Learning Objectives	To expose onto the primary tools by which the flood of information from Computational Science is analyzed.
6	Brief Contents	Introduction of computer graphics, Graphic Displays and the algorithms; Three Dimensional aspects of graphics; Transformations; Windowing and Clipping concepts; Hidden Lines and Surfaces etc.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	List of text books/references	1.Computer Graphics, C Version Donald D Hearn, M. Pauline Baker 2. Computer Graphics: Principles and Practice by James D. Foley, Andries van Dam , Steven K. Feiner

1	Code of the subject	CS303
2	Title of the subject	Trustworthy Artificial Intelligence
3	Prerequisite	
4	L-T-P	3-0-2
5	Learning Objectives	To understand the techniques and concepts related to machine based reasoning systems through various applications of AI
6	Brief Contents	Introduction to AI and intelligent agents. Problem solving methods in AI, Informed and uninformed search strategies, knowledge representation, Uncertain Knowledge and Reasoning, Probabilities, Bayesian Networks. Overview of different forms of learning, Learning Decision Trees, Artificial Neural Networks and Fuzzy Approaches; Logic in AI, Prolog, Modern AI language and tools etc.
7	Contents for lab	Experiments are based on the theoretical contents and their applications

8	Text /references	<p>1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003</p> <p>2. Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill</p> <p>Reference Books:</p> <p>1. Patrick Henry Winston, Artificial Intelligence, Pearson publication</p> <p>2. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India)</p> <p>3. Eugene Charnaik and Drew McDermott, Introduction to Artificial Intelligence, Pearson publication</p> <p>4. Nils John Nilsson, The Quest for Artificial Intelligence: A History of Ideas and Achievements, Morgan Kaufman</p> <p>5. Dennis Rothman, Artificial Intelligence by Example</p>
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1	Code of the subject	EE206
2	Title of the subject	Microprocessor and Interfacing
3	Any prerequisite	EE103
4	L-T-P	3-0-2
5	Learning Objectives of the subject	<p>Upon completion of this course, the student will be able to:</p> <ul style="list-style-type: none"> • To develop background knowledge and core expertise in microprocessor. • To study the concepts and basic architecture of 8085, and 8086 processor. • To know the importance of different peripheral devices and their interfacing to 8086. • To know the design aspects of basic microprocessor. • To write assembly language programs in microprocessor for various application
6	Brief Contents	<p>Microprocessors-Evolution and Introduction, Microprocessor based system, Origin of Microprocessor, Classification of Microprocessors, Types of Memory, I/O Devices, Technology Improvements Adapted to Microprocessors and Computers, Introduction to 8085 processor, Architecture of 8085, Microprocessor instructions, classification of instructions, Instruction set of 8085, Basic 80x86 Architecture, Role of Microprocessor in Micro Computer, Features of 8086, Internal Block Diagram of 8086, Execution Unit, Bus Interface Unit, Programming of x86 processor, Interrupt mechanism of x86 & Interfacing of chips, Advanced Processor Technologies</p> <p>Interfacing of Data Converters (D-To-A and A-To-D), Programmable Interfacing Devices Like 8255A PPI, 8253/8254 Timer, 8259A PIT, Serial I/O Concepts, SID And SOD, 8251A USART. Interfacing of above chips with 8085.</p>

7	Contents for lab	Assembly language programs for 8085 and 8086, Programs involving Arithmetic & logical operations, Programs involving data transfer instructions, programs involving bit manipulation instructions, programs involving branch/ loop instructions, Interfacing Experiments.
8	List of text books/references	Text/ Reference Books: <ul style="list-style-type: none"> • Microprocessors and Interfacing by Douglas V. Hall • The 8051 Microcontroller and Embedded Systems by M.A. Mazidi and J. G. Mazidi, PHI. • The Intel Microprocessors by Barry B. Brey, Prentice Hall. • The 8088 and 8086 Microprocessors by Walter A. Triebel, Avtar Singh, Prentice Hall Inc. • 8086/8088 family: Design, Programming and Interfacing by John Uffenbeck, Prentice Hall. • Advanced Microprocessor and Peripherals, Architecture Programming and Interfacing by A. K. Ray and K. M. Burchandi, Tata McGraw Hill. • Microcontroller and Embedded Systems by M. A. Mazidi, Pearson Education. • 8051 Microcontroller and Embedded Systems by R. Kapadia, Jaico Publishing House. • Fundamentals of Microprocessors and Microcomputers by B. Ram, Dhanpat Rai Publications.

1	Code of the subject	CS305
2	Title of the subject	Optimization Techniques
3	Prerequisite	Engineering mathematics, programming
4	L-T-P	3-1-0
5	Learning Objectives	To equip with the engineering problem formulation skills and optimization approaches to solve the problems along with quantitative analysis of those.
6	Brief Contents	Types of OR models, linear programming, problem formulation, graphical solution, simplex method, artificial variables techniques, two-phase method, big-M method etc. Transportation and assignment problems, Sequencing and Replacement, Theory of games and inventory, Dynamic Programming, engineering applications.
7	List of text books/references	1. J. K. Sharma, "Operations Research", Macmillan, 5th Edition, 2012. 2. R. Pannervan, "Operations Research", 2nd Edition, PHI Publications, 2006

1	Code of the subject	ENxxx
2	Title of the subject	Art of Engineering Research
3	Prerequisite	Engineering mathematics, programming
4	L-T-P	2-0-0
5	Learning Objectives	<p>Knowledge and understanding to recognize the ethical principles of conducting applied research, to identify various sources of information, to identify and formulate research problem.</p> <p>Intellectual skills to carry out literature searches and ability to critically evaluate literature, to design/conduct experiments, devise appropriate measurements, analyse data and form conclusions.</p> <p>Professional and practical skills to undertake and manage a research projects, to document all aspects of the development of an engineering project.</p> <p>General and transferrable skills to apply project management skills to research activities, to communicate effectively in written and oral ways.</p>
6	Brief Contents	<p>Introduction and Overview: Introduction to Research Methodology, Research types and applications, Research management, Research phases, Research problem formulation, Academic honesty.</p> <p>Literature Review: How to read journal papers, Literature review process, Information sources, Synthesizing information, Writing the literature review, Referencing.</p> <p>Thesis Proposals: Thesis Proposal main sections, How to write Thesis Proposals.</p> <p>Modeling and Simulation: MATLAB Tool Boxes overview, Building math models in MATLAB or any other tool, Simulation and results analysis.</p> <p>Engineering Experiments: Experiment set-up (Lab Work), Running experiments (Lab Work), Data collection and analysis.</p> <p>Writing Research Papers: How to write research paper, Technical writing, Where to submit, How to submit. Writing and submit research paper.</p>
7	Text /references	<p>1. Engineering Research Methodology: A Computer Science and Engineering and Information and Communication Technologies Perspective by Krishnan Nallaperumal 1st edition PHI Learning Pvt. Ltd., New Delhi, India 2014</p>

		<p>2. Research Methodology: Methods and Techniques by Kothari 2nd edition 2004</p> <p>3. Research Guide for Post-Graduate Students by Andre Buys. University of Pretoria 2007</p> <p>4. Emerging Methodologies in Engineering Education Research by Case and Light, Journal of Engineering Education 2011</p> <p>5. Designing Requirements Engineering by Wieringa and Heerkens</p> <p>6. Development Research Methods: Creating Knowledge from Instructional Design and Development Practice by Richey and Klein. Journal of Computing in Higher Education 2005</p> <p>7. Scientific Research Methodologies and Techniques by Luis Camarinha-Matos</p> <p>8. How to Read an Engineering Research Paper by William Griswold, UC at San Diego</p> <p>10. How to Write an Effective Literature Review by Sonia Martinez, University of California</p> <p>11. Models of Dissertation Research in Design by Poggenpohl and Sato, Illinois Institute of Technology</p> <p>12. On the ability to design engineering experiments by Du, Furman, and Mourtos. 8th UICEE Annual Conference on Engineering Education</p> <p>13. How to write a research journal article in engineering and science by Socolofsky</p>
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1	Code of the subject	CS306
2	Title of the subject	Machine Learning
3	Prerequisite	Linear Algebra
4	L-T-P	3-0-2
5	Learning Objectives	To understand popular ML algorithms with their associated mathematical foundations and use them for solving real world problems as machine learning tasks
6	Brief Contents	Introduction and Fundamentals of ML. Selected Algorithms - Ensembling and RF, Linear SVM, K Means, Logistic Regression, Naive Bayes etc. Neural Network Learning - Role of Loss Functions and Optimization, Gradient Descent and Perceptron/Delta Learning, MLP, Backpropagation, MLP for Classification and Regression, Regularisation, Early Stopping. Kernels (with SVM), Bayesian Methods, Generative Methods, HMM, EM, PAC learning. Introduction to Deep Learning,

		CNNs, Popular CNN Architectures, RNNs, GANS and Generative Models, Advances in Backpropagation and Optimization for Neural Networks Adversarial Learning
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	<ol style="list-style-type: none"> 1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press 2. Tom M. Mitchell, Machine Learning - McGraw Hill Education, International Edition 3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media, Inc. 2nd Edition 4. Ian Goodfellow, Yoshoua Bengio, and Aaron Courville, Deep Learning MIT Press Ltd, Illustrated edition 5. Christopher M. Bishop, Pattern Recognition and Machine Learning - Springer, 2nd edition 6. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction - Springer, 2nd edition

1	Code of the subject	CS307
2	Title of the subject	Information Security Systems
3	Prerequisite	
4	L-T-P	3-0-2
5	Learning Objectives	This course provides a comprehensive study of the security principles and practices of information systems. Helps build a good understanding of the foundational theory behind computer security and the threats.
6	Brief Contents	Security issues in computing, communications, and electronic commerce. Goals and vulnerabilities; legal and ethical issues; basic cryptology; private and authenticated communication; electronic commerce; software security; viruses and other malicious code; operating system protection; trusted systems design; network security; firewalls; policy, administration and procedures; auditing; physical security; disaster recovery; reliability; content protection; privacy.
7	Contents for lab	Experiments are based on the theoretical contents and their applications

8	Text /references	<ol style="list-style-type: none"> 1. William Stallings and Lawrie Brown. 2014. Computer Security: Principles and Practice (3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA. 2. Behrouz A. Forouzan. 2007. Cryptography & Network Security 3. M. Stamp, Information Security: Principles and Practice, Wiley 4. M. E. Whitman and H. J. Mattord, Principles of Information Security.
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1	Code of the subject	CS401
2	Title of the subject	Natural Language Processing
3	Prerequisite	AI and ML
4	L-T-P	3-0-2
5	Learning Objectives	To equip the learners with fundamental and advanced aspects of NLP applications.
6	Brief Contents	<p>Human language processing paradigms; Phases in natural language processing, applications. Text representation in computers, encoding schemes. Introduction to corpus, elements in balanced corpus, TreeBank, PropBank, WordNet, VerbNet etc. Resource management with XML, Management of linguistic data with the help of GATE, NLTK. Regular expressions, Finite State Automata, word recognition, lexicon. Morphology, acquisition models, Finite State Transducer. N-grams, smoothing, entropy, HMM, ME, SVM, CRF.</p> <p>Speech tagging. Review of natural language grammars, lexeme, phonemes, phrases and idioms, word order, agreement, tense, aspect and mood and agreement, Context Free Grammar, spoken language syntax. Parsing, Word Sense Disambiguation, Discourse- Reference resolution etc. Applications of NLP, Summarization Information, Machine Translation overview.</p>
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	Daniel Jurafsky and James H Martin, Speech and Language Processing: An introduction to Natural Language Processing, Computational Linguistics and Speech Recognition, Prentice Hall, 2nd Edition, 2008.

1	Code of the subject	CS402
2	Title of the subject	Digital Image Processing
3	Prerequisite	Mathematics
4	L-T-P	3-0-2
5	Learning Objectives	To introduce the basic concepts of Digital image processing with emphasis on applications in various field of recent research.
6	Brief Contents	Introduction and Fundamentals, Image Enhancement in Spatial Domain, Image Enhancement in Frequency Domain, Image Restoration, Segmentation, Representation and Description.
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	1.Digital Image Processing 2nd Edition, Rafael C. Gonzalvez and Richard E. Woods. Published by: Pearson Education. 2.R.J. Schalkoff ,Digital Image Processing and Computer Vision John Wiley and Sons, NY. 3. William K. Prat, Digital Image Processing, John Wiley and Sons, NY

1	Code of the subject	CS403
2	Title of the subject	Cloud Computing
3	Any prerequisite	Computer Networks, OS, Software engineering, Distributed Computing
4	L-T-P	3-0-2
5	Learning Objectives	To equip with the enabling technology for an on-demand access to a shared pool of configurable computing resources. To introduce various aspects of cloud computing paradigm and future research trends.
6	Brief Contents	Introduction to Cloud Computing, Introduction to Parallel and Distributed Computing, Cloud Computing Architecture, Service Management, Data Management in Cloud Computing, Virtualization & Resource Management, Cloud Security, Open Source and Commercial Clouds, Cloud Simulator, Research trend in Cloud Computing, Fog Computing.
7	Contents for lab	Experiments are based on the theoretical contents and their applications

8	Text /references	<ol style="list-style-type: none">1. Cloud Computing: Principles and Paradigms, Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley2. Enterprise Cloud Computing - Technology, Architecture, Applications, Gautam Shroff, Cambridge University Press3. Cloud Computing Bible, Barrie Sosinsky, Wiley-India4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley
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1	Code of the subject	CS404
2	Title of the subject	Big Data Analytics
3	Prerequisite	
4	L-T-P	3-0-2
5	Learning Objectives	Understanding of core concepts behind big data problems, applications, systems and the techniques along with an introduction to some of the most common Big Data frameworks and Big Data Streaming Platforms.
6	Brief Contents	<p>Introduction to Big Data, Enabling Technologies for Big Data, Big Data Stack, Big Data distribution packages. Big Data Platforms, Overview of Apache Spark, HDFS, YARN, Introduction to MapReduce, MapReduce Programming Model with Spark, MapReduce Example: Word Count, Page Rank etc.</p> <p>Introduction to Big Data Storage Platforms for Large Scale Data Storage, CAP Theorem, Eventual Consistency, ACID and BASE, Zookeeper and Paxos, Cassandra, HBase Big Data Streaming Platforms for Fast Data, Big Data Streaming Systems, Big Data Pipelines for Real-Time computing, Spark Streaming, Kafka, Streaming Ecosystem.</p> <p>Introduction to Big Data Applications (Machine Learning), Overview of Big Data Machine Learning, Mahout, Big Data Machine Learning Algorithms in Mahout- kmeans, Naïve Bayes etc.</p> <p>Introduction of Big Data Machine learning with Spark, Big Data Machine Learning Algorithms in Spark- Introduction to Spark MLlib, Introduction to Deep Learning for Big Data.</p> <p>Introduction to Big Data Applications (Graph Processing), Introduction to Pregel, Introduction to Giraph, Introduction to Spark GraphX.</p>
7	Contents for lab	Experiments are based on the theoretical contents and their applications
8	Text /references	<ol style="list-style-type: none"> 1. Big Data Science & Analytics: A Hands-On Approach, Arshdeep Bahga and Vijay Madisetti, VPT. 2. The Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, Bill Franks, Wiley. 3. Big Data Analytics: Disruptive Technologies for Changing the Game, ArvindSathi, MC Press. 4. Hadoop: The Definitive Guide, Tom White, O'Reilly.

1	Code of the subject	CS498
2	Title of the subject	Colloquium (Based on industrial training)/ MOOC
3	Prerequisite	
4	L-T-P	0-0-6
5	Learning Objectives of the subject	<p>To instill the ability to identify skills and gain practical work experience</p> <p>To provide an opportunity to observe and contribute in the workplace</p> <p>To take ownership and responsibility of a project assignment, given by a designated manager/supervisor</p> <p>To provide networking opportunities with other members of the organization</p> <p>To offer performance feedback and mentorship throughout the internship</p>
6	Brief Contents	<p>An internship helps you train under experienced professionals and explore what your chosen career path would be like, and an internship with a company in your field can help you to develop the skills you require to thrive within a professional setting. At the end of the training period, the company may ask you to review your time with them and write a report based on your experience. In addition, hone the skills needed to develop internship report.</p>
7	Contents for lab	<p>There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.</p>
8	Text /references	<ol style="list-style-type: none"> 1. https://www.careereducation.columbia.edu/resources/10-tips-make-most-internship 2. https://in.indeed.com/career-advice/career-development/internship-report

1	Code of the subject	CS499
2	Title of the subject	BTech Project/ Internship
3	Any prerequisite	
4	L-T-P	0-0-24
5	Learning Objectives	To develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.
6	Brief Contents	The purpose of this course is to enable the student to develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study. The student is expected to demonstrate the abilities of the major subject/field of study, including deeper insight into hardware/software application development work. Develop the capability to create, analyse and critically evaluate different technical/architectural solutions. Equip with the needed skills to clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for the learning outcome in written and spoken English. Importantly it is necessary to march on the ethical aspects of research and development work.
7	Contents for lab	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	List of text books/references	https://grad.wisc.edu/wp-content/uploads/sites/329/2018/02/2018-Project-Management-for-Graduate-Students-Course-Workbook.pdf

1	Code of the subject	CS001
2	Title of the subject	Graph Theory
3	Prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives	To teach the applications of game theory, auction and equilibrium.
6	Brief Contents	Introduction to Game Theory, Dominant Strategies and Nash Equilibrium, Alternate Strategies: Maximin, Maximax, and Minimax Regret Solvability, N-Player Games, Mixed Strategy Nash Equilibria, Subgame Perfection in Discrete Choice Games, Continuous Games and Imperfect Competition, Infinitely Repeated Games, Tacit Collusion: An application of Infinites Repeated Games, imperfect Information: Simultaneous-play, ayesian Games, Applications of Bayesian Games: Auctions and Voting, Cournot's Duopoly with Imperfect Information 3.Radio Spectrum, With Arbitrary Distribution of Valuations, Extensive Form Game with Perfect Information, Stackelberg Model of Duopoly, Buying Votes, Committee Decision-Making, Repeated games, The Prisoner's Dilemma, General Result, Supermodular Game and Potential Game, Supermodular Game and Potential Game, Wireless Networks: Resource Allocations, Admission Control, Routing in Sensor and Ad-Hoc Networks, Modeling Network Traffic and Strategic Network Formation, Rubinstein Bargaining Model with Alternating Offers, Nash Bargaining Solution, Relation of Axiomatic and Strategic Model, Auction and Mechanism Design with Applications, Revenue Equivalence, Risk Averse Bidders, Asymmetries among Bidders, Mechanism, Optimal Mechanism.
7	Contents for lab	NA
8	Text books/references	<ol style="list-style-type: none"> 1. Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003 2. Prajit Dutta, Strategies and Games, MIT Press. 3. K H Ericson, Game Theory, Createspace Independent Publishing Platform.

1	Code of the subject	CS002
2	Title of the subject	Software, System Analysis and Design
3	Any prerequisite	No
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<ol style="list-style-type: none"> 1. Outline the software design process, and demonstrate how the essential design principles are applied within it. 2. Illustrate the essential elements of software structure and architecture in terms of styles, patterns and families of programs and frameworks. 3. Demonstrate the application of quality analysis and evaluation principles. 4. Employ function, object, data-structure and component-based design methodologies in a typical software design project.
6	Brief Contents	<ol style="list-style-type: none"> 1. Software Design Fundamentals: General design concepts, Context of software design, Software design process, Software design principles. 2. Key Issues in Software Design: Concurrency, Control and handling of events, Data persistence, Distribution of components, Error exception handling and fault tolerance, Interaction and presentation, Security. 3. Software Structure and Architecture: Architectural structures and viewpoints, Architectural styles, Design patterns, Architecture design decisions, Families of programs and frameworks 4. User Interface Design: General user interface design principles, User interface design issues, Design of user interaction modalities, Design of information presentation, User interface design process, Localization and internationalization, Metaphors and conceptual models 5. Software Design Quality Analysis and Evaluation: Quality attributes, Quality analysis and evaluation techniques, Measures. 6. Software Design Notations: Structural descriptions (static view), Behavioral descriptions (dynamic view). 7. Software Design Strategies and Methods: General strategies, Function-oriented (structured) design, Object-oriented design, Data structure-oriented design, Component-based design, other methods.
7	Contents for lab	Assignments

8	List of books/text	<p>1. Systems Analysis and Design (MindTap Course List) 12th Edition by Scott Tilley, 2019.</p> <p>2. Head First Design Patterns: Building Extensible and Maintainable Object-Oriented Software 2nd Edition 2nd Edition by Eric Freema.</p> <p>3. Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems Kindle Edition by Martin Kleppmann.</p>
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1	Code of the subject	CS003
2	Title of the subject	Digital Signal Processing
3	Prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives	<p>In this course, we will mainly study the following topics: signal representation in time domain, Fourier transform, sampling theorem, linear time-invariant system, discrete convolution, z-transform, discrete Fourier transform, and discrete filter design. After this course, the students should be able to understand how to analyse a given signal or system using tools such as Fourier transform and z-transform; how to process signals to make them more useful.</p>
6	Brief Contents	<p>Module I: Review of Signals and Systems: Discrete time complex exponentials and other basic signals-scaling of the independent axis and differences from its continuous-time counterpart-system properties (linearity, time-invariance, memory, causality, BIBO stability)-LTI systems, convolution, correlation, continuous-time Fourier series and Fourier transform.</p> <p>Module II: Sampling: Impulse train sampling and reconstruction, aliasing, A/D and D/A conversion, quantization noise. Discrete-Time Fourier Transform (DTFT): Complex exponentials as Eigen signals of LTI systems-DTFT definition-inversion formula-properties-relationship to continuous-time Fourier series (CTFS). Z-Transform: Generalized complex exponentials as eigensignals of LTI systems-z-transform definition-region of convergence (RoC)-properties of RoC-properties of the z-transform,</p>

		<p>inverse z-transform methods, pole-zero plots, RoC implications of causality and stability.</p> <p>Module III: Frequency Domain Analysis of LTI Systems: Frequency response of systems with rational transfer function, definitions of magnitude and phase response, geometric method of frequency response evaluation from pole-zero plot, frequency response of single complex zero/pole, frequency response of filters.</p> <p>Module IV: Discrete Fourier Transform (DFT): Definition of the DFT and inverse DFT-circular shift of signal and the $\text{—index mod } N\$ concept-properties of the DFT-circular convolution and its relationship with linear convolution—sectioned convolution methods: overlap add and overlap save-effect of zero padding.</p>
7	Contents for lab	
8	Text /references	<ol style="list-style-type: none"> 1. Discrete-Time Signal Processing by Alan V. Oppenheim and Ronald W. Schaffer, 3rd edition, 2010, Prentice Hall, Upper Saddle River, NJ. 2. Digital Signal Processing by SanjitMitra, 4th edition, 2011, McGraw-Hill, New York, NY.

1	Code of the subject	CS004
2	Title of the subject	Data Analytics and Visualisation
3	Prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives	<ol style="list-style-type: none"> 1. Provide an overview of the statistical tools used to process, analyse, and visualize data. 2. Form testable hypotheses that can be evaluated using common statistical analyses.
6	Brief Contents	Introduction to the science of statistics: Fundamental elements of Statistics, Qualitative and Quantitative Data Summaries, Normal distribution, Sampling, Central Limit Theorem.

		<p>Confidence intervals and hypothesis tests: Statistical Inference, Stating Hypotheses, Test Statistics and p-Values, Evaluating Hypotheses, Significance Tests and Confidence Intervals, Inference about a Population Mean, Two-Sample Problems</p> <p>Parametric association: Scatterplots, Correlation, Simple Linear Regression, F-test for Simple Linear Regression, t-test for Simple Linear Regression.</p> <p>Multiple linear regression: Equation of multiple linear regression, Interpretation of multiple linear regression, F-test for Multiple Linear Regression, t-tests in Multiple Linear Regression, Cautions about Regression</p> <p>Analysis of Variance (ANOVA): One-Way Analysis of Variance, F-test for ANOVA, Evaluating Group Differences, Type I and Type II Errors, Issues with Multiple Comparisons, Assumptions of Analysis of Variance, Relationship between One-Way ANOVA and Regression, One-Way Analysis of Covariance, Two-Way Analysis of Variance, Two-Way Analysis of Covariance</p> <p>Analysis for proportions: One-Sample Tests for Proportions, Significance Tests for a Proportion, Confidence Intervals for a Proportion, Two-Sample Tests for Proportions, Confidence Intervals for Differences in Proportions, Significance Tests for Differences in Proportions, Effect Measures, Logistic Regression, Multiple Logistic Regression, Area under the ROC Curve.</p>
7	Contents for lab (If applicable)	Implementation of data analytics methods using R or Python.
8	Text books/references	<ol style="list-style-type: none"> 1. Andy Field, Jeremy Miles and Zoe Field, "Discovering Statistics Using R", SAGE Publications Ltd (2012). 2. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani "An Introduction to Statistical Learning with Applications in R", Springer (2013).

1	Code of the subject	CS005
2	Title of the subject	Cryptography and Network Security
3	Prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives	To develop a framework to understand and implement cryptographic aspects. To enhance an ability to analyze a problem, and identify and define the computing requirements for data security. To prepare abstract and

		critical thinking background for computer science students
6	Brief Contents	<p>Module I- Introduction Classical Encryption Techniques: Symmetric Cipher Model, Substitution Techniques, Transposition Techniques, Stream Cipher and Block Cipher, Random Number Generator, One-time Pad.</p> <p>Module II- Finite Field and Number Theory Groups, Rings, Fields, Modular Arithmetic, Euclid's Algorithm, Finite Fields Of Form $GF(p)$ And $GF(2^n)$. Polynomial Arithmetic, Prime Numbers, Fermat's And Euler's Theorem, Testing For Primality, The Chinese Remainder Theorem, Discrete Logarithms.</p> <p>Module III-Symmetric Cipher and Public Key Encryption Block Cipher Principles, Data Encryption Standard (DES), Multiple Encryption, Triple DES, Advanced Encryption Standard (AES), Principles of Public Key Cryptosystems, The RSA Algorithm, Key Management, Elliptic Curve Arithmetic, Elliptic Curve Cryptography.</p> <p>Module IV-Cryptographic Protocols Authentication Requirement, Authentication Function, MAC, Hash Functions, Security of Hash Function , Digital Signatures,</p> <p>Module V-Network Security and Applications Authentication applications: Kerberos – X.509 Authentication services, Public Key Infrastructure, Pretty Good Privacy, S/MIME IP security: Encapsulating Security Payload (ESP)-Internet Key Exchange (Phases of IKE, ISAKMP/IKE Encoding) Web Security: Web Security Considerations, Secure Socket Layer and Transport layer Security System Security: Intruders, Intrusion Detection, Virus and related threats, Virus Countermeasures, Firewalls, Firewalls Design Principles, Trusted System</p>
7	Contents for lab	
8	List of text books/references	<ol style="list-style-type: none"> 1. William Stallings, Cryptography and Network security, 4e, Prentice Hall of India, New Jersey, 2008. 2. Christof Paar, Jan Pelzl, Understanding Cryptography, Springer-Verlang, Berlin, 2010 3. Behrouz A Forouzan, Cryptography and Network security, Tata Mc-Graw Hill, New York, 2007.

1	Code of the subject	CS006
2	Title of the subject	Control System Engineering
3	Prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives	To be able to obtain a working mathematical model of a system. To be able to do time-domain and frequency-domain analyses of the model to predict the system's behaviour. To be able to design control systems that meet design specifications.
6	Brief Contents	Introduction, Mathematical modelling, Time response of dynamical systems, Stability, feedback control, Design of controllers, Frequency domain analysis, design of compensators
7	Contents for lab	
8	Text books/references	1. G.F. Franklin, J. D. Powell, A. Emami-Naeini, "Feedback Control of Dynamic Systems", Pearson, Upper Saddle River, New Jersey, 5th edition, 2006. 2. K. Ogata, "Modern Control Engineering", Prentice-Hall of India Pvt Ltd., New Delhi, 3rd edition, 2000. 3. B. C. Kuo, "Automatic Control Systems", Prentice-Hall of India Pvt Ltd., New Delhi, 6th, edition, 1991. 4. Nagrath & Gopal, Control Systems

1	Code of the subject	CS007
2	Title of the subject	System Simulation and Modeling
3	Prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives	Introduce computer simulation technologies and techniques, provide the foundations for the student to understand computer simulation needs, and to implement and test a variety of simulation and data analysis libraries and programs To introduce concepts of modeling layers of society's critical infrastructure networks and to build tools to view and control simulations and their results.
6	Brief Contents	Module – 1 Simulation Basics : Handling Stepped and Event-based Time in Simulations, Discrete versus Continuous Modelling, Numerical Techniques, Sources and Propagation of Error

		<p>Module – 2 Dynamical, Finite State, and Complex Model Simulations: Graph or Network Transitions Based Simulations, Actor Based Simulations, Mesh Based Simulations, Hybrid Simulations</p> <p>Module – 3 Converting to Parallel and Distributed Simulations : Partitioning the Data, Partitioning the Algorithms, Handling Inter-partition Dependencies</p> <p>Module – 4 Probability and Statistics for Simulations and Analysis : Review of terminology, concepts, Useful statistical models, Discrete Distributions ,Continuous Distributions, Poisson Process, Empirical distributions, Introduction to Queues and Random Noise, Random Variates Generation, Sensitivity Analysis, The basics of SpreadSheet-Simulation, Simulation Example: Simulation of queuing systems in a spreadsheet</p> <p>Module 5- Random-Number Generation, Random-Variate Generation : Properties of random numbers, Generation of pseudo-random numbers ,Techniques for generating random numbers ,Tests for Random Numbers, Random- Variate Generation ,Inverse transform technique ,Acceptance-Rejection technique, Special properties</p> <p>Module 6 -Input Modeling: Data Collection, Identifying the distribution with data, Parameter Estimation, Goodness of Fit Tests, Fitting a non-stationary Poisson process ,Selecting input models without data , Multi-variate and Time-Series input models</p> <p>Module 7- Queuing Models: Characteristics of queuing Systems, Queuing notation , Long-run measures of performance of queuing Systems, Steady-state behavior of M/G/1 queue, Networks of queues ,Rough-cut modeling: An illustration.</p> <p>Module – 8 Simulations Results Analysis and Viewing Tools : Display Forms: Tables, Graphs, and Multidimensional Visualization, Terminals, X and MS Windows, and Web Interfaces, Validation of Model Results.</p>
7	Contents for lab	
8	Text books/references	<ol style="list-style-type: none"> 1. Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event System Simulation. (Listed topics only from Chapters-1 to 12), 5th Edition, Pearson Education ©2013 2. Averill M. Law: Simulation Modeling and Analysis , 4th Edition, Tata McGraw-Hill, 2007.ISBN : 9780070667334

		3. Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course, Pearson Education, 2006. ISBN: 978-0131429178
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1	Code of the subject	CS008
2	Title of the subject	IoT Protocols
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<p>To introduce the terminology, technology and its applications</p> <p>To introduce the concept of M2M (machine to machine) with necessary protocols</p> <p>To introduce the Python Scripting Language which is used in many IoT devices</p> <p>To introduce the Raspberry PI platform, that is widely used in IoT applications</p> <p>To introduce the implementation of web-based services on IoT devices</p>
6	Brief Contents	<p>Module 1: Introduction to Signals and systems, Introduction to Internet of Things, Physical Design of IoT – IoT Protocols, IoT communication models, IoT Communication APIs, IoT enabled Technologies – Wireless Sensor Networks, Cloud Computing, Embedded Systems, IoT Levels and Templates, Domain Specific IoTs – Home, City, Environment, Energy, Agriculture and Industry.</p> <p>Module 2: IoT and M2M- Software defined networks, network function virtualization, difference between SDN and NFV for IoT, Basics of IoT System Management with NETCONF, YANG- NETCONF, YANG, SNMP NETOPEER</p> <p>Module 3: IoT Physical Devices and Endpoints- Introduction to Arduino and Raspberry Pi- Installation, Interfaces (serial, SPI, I2C) Controlling Hardware- Connecting LED, Buzzer, Switching High Power devices with transistors, Controlling AC Power devices with Relays, Controlling servo motor, speed control of DC Motor, unipolar and bipolar Stepper motors</p> <p>Module 4: Sensors- Light sensor, temperature sensor with thermistor, voltage sensor, ADC and DAC, Temperature and Humidity Sensor DHT11, Motion Detection Sensors, Wireless Bluetooth Sensors, Level Sensors, USB Sensors, Embedded Sensors, Distance Measurement with ultrasound</p>

		sensor Module 5: IoT Physical Servers and Cloud Offerings– Introduction to Cloud Storage models and communication APIs Web Server – Web server for IoT, Cloud for IoT, Python web application framework Designing a RESTful web API
7	Contents for lab (If applicable)	
8	List of text books/references	1. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madiseti, Universities Press, 2015, ISBN: 9788173719547 2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759 3. Raspberry Pi Cookbook, Software and Hardware Problems and solutions, Simon Monk, O'Reilly (SPD), 2016, ISBN 9789352133895

1	Code of the subject	CS009
2	Title of the subject	Game Programming
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	This course provides an introduction to game engine scripting, event driven and data driven programming, game engine data structures, basic game related graphics and AI concepts.
6	Brief Contents	Module 1: Introduction to Game Programming and Unity, The Game Loop, Scene Modeling Module 2: Introduction to Animation, Keyframing, Character Animation and Rigging, Animation Controllers, Game UIs Module 3: Kinematics, Particle Effects, Physics-based Animation, Numerical Integration, Rigid Body Simulation, Collisions, Sound, Procedural Content Generation Module 4: Game AI: Planning, Pathfinding, Decision Making Module 5: Game Networking, Game Business and Ethics
7	Contents for lab (If applicable)	
8	List of text books/references	1. Mike Mc Shaffrly and David Graham, "Game Coding Complete", Fourth Edition, Cengage Learning, PTR, 2012. 2. Jason Gregory, "Game Engine Architecture", CRC Press / A K Peters, 2009. 3. David H. Eberly, "3D Game Engine Design, Second Edition: A Practical Approach to Real-Time Computer Graphics" 2nd Editions, Morgan Kaufmann, 2006.

		<p>4. Ernest Adams and Andrew Rollings, "Fundamentals of Game Design", 2nd Edition Prentice Hall / New Riders, 2009.</p> <p>5. Eric Lengyel, "Mathematics for 3D Game Programming and Computer Graphics", 3rd Edition, Course Technology PTR, 2011.</p> <p>6. Jesse Schell, The Art of Game Design: A book of lenses, 1st Edition, CRC Press, 2008.</p>
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1	Code of the subject	CS010
2	Title of the subject	Formal Languages and Automata
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<p>To discuss key notions of computation, such as algorithm, computability, decidability, reducibility, and complexity, through problem solving.</p> <p>To explain the models of computation, including formal languages, grammars and automata, and their connections.</p> <p>state and explain the Church-Turing thesis and its significance.</p> <p>To analyze and design finite automata, pushdown automata, Turing machines, formal languages, and grammars.</p> <p>To solve computational problems regarding their computability and complexity and prove the basic results of the theory of computation.</p>
6	Brief Contents	<p>Module I: Automata and Languages - finite automata and regular expressions, pushdown automata and context-free grammars, pumping lemmas and closure properties of regular and context-free languages, non-context-free languages</p> <p>Module II: Computability theory - the Church-Turing thesis, Hilbert's problem, decidability, halting problem, reducibility</p> <p>Module III: Complexity theory - time and space complexity, Classes P, NP, NP-complete, PSPACE, and PSPACE-complete</p> <p>Module IV: Intractability - hierarchy theorem, Relativization, Circuit complexity</p> <p>Module V: Computable Functions- Primitive Recursive Functions, PRF and Bounded Operations, Unbounded. Minimalization and μ-Recursive Functions, Godel Numbering</p>

7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. M. Sipser, Introduction to the Theory of Computation, Thomson, 2004. 2. H. R. Lewis and C. H. Papadimitriou, Elements of the Theory of Computation, PHI, 1981. 3. J. L. Balcazar, J. Diaz and J. Gabarro, Structural Complexity, Vols 1 & 2, EATCS Monographs, Springer-Verlag, 1987. 4. John Martin. (2010). Introduction to languages and the theory of computation, (4th ed.). New York: McGraw-Hill Science/Engineering/Math. 5. Turlakis, George J. (2012). Theory of computation. Hoboken: Wiley.

1	Code of the subject	CS011
2	Title of the subject	Advanced Network Technologies
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	To understand the interconnection for high performance computing, protocols and techniques used for enhancing data delivery ratio, ensuring QoS. Wireless sensor networks and protocols to support cyber physical system interaction and components of IoT.
6	Brief Contents	<p>Module 1: Gigabit Networking High Performance Computing and Communications Program (HPCC) basics, Broadband networks, Gigabit testbeds worldwide, Network switching technologies: architecture and performance parameters, Gigabit network design preliminaries.</p> <p>Module 2: Wireless Sensor Networks Sensor network architecture, Design principles, Optimization goals and figures of merit, Communication protocols, Link layer protocols, Localization and positioning, Topology control, Routing protocols, Advanced application support.</p> <p>Module 3: Content Delivery Networks Early Days of Content Delivery over the Internet World Wide Web—Where It Came From and What It Is Evolution of Content Networking Diversity of Interests in Content Networking; Content Transport: Protocol Architecture and Design Paradigms of the Internet, Hypertext Transport Protocol—HTTP, Multicast Transport; Caching Techniques for Web Content; Caching Techniques for Streaming Media.</p>
7	Contents for lab (If applicable)	
8	List of text books/references	1. —Gigabit Networking (Addison-Wesley Professional Computing Series), Craig Partridge, Addison Wesley, 1994. 2. —Protocol and Architectures for Wireless Sensor Networks , Holger Karl, Andreas Willig, Wiley, 2005. 3. —Content Networking Architecture, Protocols, and Practicell , M. Hofmann, L. R. Beaumont, .Morgan Kaufmann, 2005.

1	Code of the subject	CS012
2	Title of the subject	Empirical Techniques in Software Engineering
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<ol style="list-style-type: none"> 1. Design empirical studies for different purposes (e.g., evaluating a tool, understanding a phenomenon); choose appropriate methods and defend the choice. 2. Collect and analyze qualitative and quantitative data 3. Mine data from online repositories. 4. Run statistical tests and interpret results. 5. Draw conclusions from empirical data.
6	Brief Contents	<p>What Is Empirical Software Engineering? Overview of Empirical Studies, Types of Empirical Studies, Empirical Study Process, Basic Elements of Empirical Research</p> <p>Software Metrics: Measurement Basics, OO metrics, dynamic metrics, System Evolution and Evolutionary Metrics, validation of software metrics.</p> <p>Experimental design: Overview of Experimental Design, Research Questions, Research Variables, Hypothesis Formulation, Data Collection, selection of Data analysis methods.</p> <p>Mining Data from Software Repositories: Configuration Management Systems, Importance of Mining Software Repositories, version control system, bug tracking systems, static source code analysis, software historical analysis.</p> <p>Data Analysis and Statistical Testing, Model Development and Interpretation, Validity Threats, Categories of Threats to Validity.</p>
7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. Empirical Research in Software Engineering Concepts, Analysis, and Applications By Ruchika Malhotra. 2. Clases Wohlin, Per Runeson, Martin Host, Magnus C. Ohlsson, Bjorn Regnell, Anders Wesslen Experimentation in Software Engineering: An Introduction November 1999, Kluwer Academic Pub. 3. Tonella P., Torchiano, M., Du Bois, B., Systa, T. 2007. Empirical studies in reverse engineering: state of the art and future trends. In Empirical Software Engineering, Vol. 12(5), Springer, 551-571

1	Code of the subject	CS013
2	Title of the subject	Digital Water Marking and Steganalysis
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	The objective of the course makes students familiar about Digital watermarking and steganography.
6	Brief Contents	<p>Module I-Introduction: Information Hiding, Steganography, and Watermarking, Importance of Digital Watermarking, Steganography</p> <p>Applications and Properties: Applications of Watermarking, Applications of Steganography, Properties of Watermarking Systems, Evaluating Watermarking Systems, Properties of Steganographic and Steganalysis Systems, Evaluating and Testing Steganographic Systems</p> <p>Module II-Models of Watermarking: Communication-Based Models of Watermarking, Geometric Models of Watermarking, Modeling Watermark Detection by Correlation,</p> <p>Basic Message Coding: Mapping Messages into Message Vectors, Error Correction Coding, Detecting Multi-symbol Watermarks</p> <p>Module III- Watermarking with Side Information: Informed Embedding, Watermarking Using Side Information, Dirty-Paper Codes</p> <p>Robust Watermarking: Approaches, Robustness to Volumetric Distortions, Robustness to Temporal and Geometric Distortions</p> <p>Module IV- Watermark Security: Security Requirements, Watermark Security and Cryptography, Some Significant Known Attacks</p> <p>Content Authentication: Exact Authentication, Selective Authentication, Localization, Restoration,</p> <p>Steganography: Notation and Terminology, Information-Theoretic Foundations of Steganography, Practical Steganographic Methods, Minimizing the Embedding Impact</p> <p>Steganalysis: Steganalysis Scenarios, Some Significant Steganalysis Algorithms.</p>

7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. Digital Watermarking and Steganography, Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, Ton Kalker, Morgan Kauffman 2. Digital Watermarking principles, Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Morgan Kauffman

1	Code of the subject	CS014
2	Title of the subject	Deep Learning
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<ol style="list-style-type: none"> 1. Introduce deep learning algorithms, the problem settings, and their applications to solve real world problems. 2. Provide an understanding of the theoretical basis underlying neural networks and deep learning.
6	Brief Contents	<p>Module 1: History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptron, Perceptron Learning Algorithm.</p> <p>Module 2: Multilayer Perceptron (MLPs), Representation Power of MLPs, Sigmoid Neurons, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks</p> <p>Module 3: Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Eigenvalues and eigenvectors, Eigenvalue Decomposition, Basis.</p> <p>Module 4: Principal Component Analysis and its interpretations, Singular Value Decomposition</p> <p>Module 5: Autoencoders and relation to PCA, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders</p> <p>Module 6: Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout.</p> <p>Module 7: Greedy Layer-wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization</p>

		<p>Module 8: Convolutional Neural Networks, AlexNet, ZF-Net, VGGNet, GoogleNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks</p> <p>Module 9: Recurrent Neural Networks, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs</p> <p>Module 10: Encoder Decoder Models, Attention Mechanism, Attention over images.</p>
7	Contents for lab (If applicable)	Exploration and implementation of deep-learning models using Tensor Flow, PyTorch and Caffe.
8	List of text books/references	<ol style="list-style-type: none"> 1. Ian Goodfellow, Yoshua Benjio, Aaron Courville, "Deep Learning", The MIT Press, 2016. 2. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", John Wiley & Sons Inc. 3. Research Papers.

1	Code of the subject	CS015
2	Title of the subject	Blockchain Technology
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<ul style="list-style-type: none"> • Get an overview of blockchain technology, its history, benefits, drawbacks, and future. • Examine the nascent blockchain technology and make an initial pass at identifying some of its major vulnerabilities. • Design, build, and deploy distributed applications • Shall equip students with the skills necessary to create e-governance applications for the public good.
6	Brief Contents	<p>Module I: Introduction: Overview of Blockchain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Types of consensus algorithms, Types of Block chain -Public vs Private Block chain, Understanding Crypto currency, A basic crypto currency</p> <p>Module II: Overview of Security aspects of Block chain. Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle</p>

		<p>tree, Symmetric key cryptography, Asymmetric key cryptography, Public Key cryptography, Digital Signature.</p> <p>Module III: Byzantine General problem and Fault Tolerance, Mining Mechanism, Energy usage, Distributed Consensus, Merkle Tree, Transactions and Fee, Anonymity, Reward, Bitcoin Transaction structure, Double Spending Problem, Privacy in blockchains.</p> <p>Module IV: Introduction to Consensus Problem, Distributed Consensus, Nakamoto consensus, Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS), Leased Proof of Stake (LPoS), Proof of Elapsed Time (PEoT), Tangle, Proof of Burn (PoB), Difficulty Level, Energy utilization and alternate, Consensus in Ethereum.</p> <p>Module V: Application of DLT in e-governance, Banking and Finance, Virtual Machine- Swarm and IPFS- Installing IPFS, IPFS file uploader, Understanding blockchain for Enterprises – Project (Eg. Enterprise application of blockchain, Food security, Blockchain enabled Trade, finance network, Supply chain, and Identity on blockchain.)</p>
7	Contents for lab (If applicable)	
8	List of text books/references	<p>1. Michael E. Whitman and Herbert J. Mattord: Principles of Information Security, 2nd Edition, Cengage Learning, 2005. (Chapters 5, 6, 7, 8; Exclude the topics not mentioned in the syllabus).</p> <p>2. Behrouz A. Forouzan and Debdeep Mukhopadhyay: Cryptography and Network Security, 2nd Edition Tata McGraw Hill, 2010. (Chapters: 1, 3, 6, 7, 10, 11, 15, 16, 17, 18).</p>

1	Code of the subject	CS016
2	Title of the subject	Introduction to Robotics
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	The course work will be helpful for the students to understand the basic principles of robotics. They will learn about the components, modelling and basic operations of the robots.

6	Brief Contents	<p>Systems Overview of a Robot, Mechanical Systems, Components, Dynamics and Modeling, Control of Actuators in Robotic Mechanisms, Robotic Sensory Devices.</p> <p>Performance Definition - Accuracy/ Repeatability/ Precision with respect to Position & Path, payload, speed, acceleration, cycle time</p> <p>Challenges/ applications and uses of Mobile and other robots: wheeled, tracked, legged, aerial, underwater robots, surgical robots, rehabilitation robots, humanoid robots</p> <p>Introduction to robot manipulation. Forward and inverse kinematics of robots and some case studies. Manipulator dynamics. Basics of robot control.</p> <p>Task planning with emphasis on computational geometry methods for robot path finding, robot arm reachability, grasp planning etc.</p> <p>Overview of robot vision.</p>
7	Contents for lab (If applicable)	
8	List of text books/references	<p>TEXT BOOKS:</p> <ol style="list-style-type: none"> 1. Richard D. Klafter, Robotic Engineering: An Integrated Approach, Phi 2. R. J. Schilling, Fundamentals of Robotics: Analysis And Control, Prentice-Hall India <p>References:</p> <ol style="list-style-type: none"> 1. Francis N. Nagy, Andrassiegler, Engineering Foundation of Robotics, Prentice Hall Inc 2. P.A. Janaki Raman, Robotics And Image Processing An Introduction, Tata Mc Graw Hill Publishing Company Ltd. 3. Mikell P. Grooyer, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics, Technology Programming And Applications, Mc Graw Hill International Edition 4. S.R. Deb, Robotics Technology And Flexible Automation, Tata Mc Graw Hill Publishing Company Ltd. 5. Carl D. Crane And Joseph Duffy, Kinematic Analysis Of Robot Manipulation, Cambridge University Press

1	Code of the subject	CS017
2	Title of the subject	Stochastic Processes and Queuing Theory
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	Many complex systems are modeled using stochastic processes. This course will introduce students to basic stochastic processes tools that can be utilized for performance analysis and stochastic modeling.
6	Brief Contents	Module 1: Review of probability, random variable and expectation Module 2: Stochastic processes Module 3: Discrete-Time Markov Chains Module 4: Continuous-Time Markov Chains Module 5: Queuing networks
7	Contents for lab (If applicable)	
8	List of text books/references	1. —Introduction to Stochastic Processes , E. Cinlar, Prentice-Hall, 1975. 2. —Stochastic Modelling of Queues , R. W. Wolf, Prentice-Hall, 1989. 3. —Probability & Statistics with Reliability, Queuing and Computer Science Application , 2nd ed., Wiley, 2008.

1	Code of the subject	CS018
2	Title of the subject	Advanced Competitive Programming
3	Any prerequisite	
4	L-T-P	3-0-0

5	Learning Objectives of the subject (in about 50 words)	To gain an in-depth knowledge of data structure and algorithms To apply different algorithms in solving real-world problems. To understand the commonly used problem solving techniques
6	Brief Contents	<p>Module I: Basic Data Structures: Arrays, Strings, Stacks, Queues, Asymptotic analysis (Big-O notation), primality testing, Euclid's GCD Algorithm, Basic Recursion, Greedy Algorithms, Naive string searching, $O(n \log n)$ Sorting, Binary Searching, Heaps (priority queue)</p> <p>Module II: Advance Data Structure: Disjoint Set Union, Segment Trees, Binary Index Tree (Fenwick tree), Trees traversals, Fundamental of Dynamic Programming, tree dynamic programming</p> <p>Module III: Graph Algorithms: Finding connected components and transitive closures. Shortest-path algorithms (Dijkstra, Bellman-Ford, Floyd-Warshall), Minimum spanning tree (Prim and Kruskal algorithms), Biconnectivity in undirected graphs (bridges, articulation points), Strongly connected components in directed graphs, Topological Sorting.</p> <p>Module IV: Modular arithmetic including division, inverse Amortized Analysis, Divide and Conquer, Advanced Dynamic Programming problems, Sieve of Eratosthenes</p> <p>Treaps, Persistent Data Structures, HLD, Centroid Decomposition, Computational Geometry, Dynamic Programming Optimizations, Advanced String algorithms (Tries, KMP, Aho-Corasik, Suffix arrays, Suffix trees), Flows (Max-Flow, Min Cost Max Flow)</p>
7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. Felix Halim and Steven Halim,—Competitive programming 3 , NUS. 2. Antti and Laaksonen, —Guide to Competitive Programming: Learning and Improving Algorithms Through Contests , 78-3319725468, Springer; 1st ed. 2017 3. Narasimha Karumanchi, —Data Structures and Algorithms made easy , CareerMonk Publications; Fifth edition, 2016.

1	Code of the subject	CS019
2	Title of the subject	Network Programming
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	The programming part of the course will be executed through in-class example discussion, homework assignments and term project. Due to the time limit, the lectures will focus mostly on networking concepts and how to achieve them with the selected languages and systems.
6	Brief Contents	Module 1: Network and Web basics, Addressing, Naming and DNS Module 2: Socket programming, TCP, UDP programming, Simple client-server programming, Network programming with GUI Module 3: Programming with HTTP for the Internet and WWW, Email, Telnet and FTP Processing XML and JSON data Module 4: Multithreading, multiprocessing, multithreaded servers and clients, Event-driven programming Module 5: Popular Python libraries for your applications
7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. Abhishek Ratan, Eric Chou, Pradeeban Kathiravelu and Dr. M. O. Faruque Sarker. Python Network Programming. Packt Publishing, 2019. 2. Eric Chou. Mastering Python Networking, 2nd Edition. Packt Publishing, 2018. 3. Josa Manuel Ortega. Mastering Python for Networking and Security. Packt Publishing, 2018. 4. Pradeeban Kathiravelu and Dr. M. O. Faruque Sarker. Python Network Programming Cookbook, 2nd Edition. Packt Publishing, 2017. 5. Dr. M. O. Faruque Sarker and Sam Washington. Learning Python Network Programming, Packt Publishing, 2015. 6. Brandon Rhodes and John Goerzen. Foundations of Python Network Programming 3rd Edition. Apress, 2014.

1	Code of the subject	CS020
2	Title of the subject	Combinatorial Mathematics
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	The course deals with theory and algorithms for solving integer and combinatorial optimization problems. Topics that are covered include models and algorithms for network flow, matching, assignment, matroids, knapsack problems, relaxations, tree search methods, and cutting plane methods.
6	Brief Contents	Fundamental concepts of graphs, trees and distance, shortest paths, disjoint paths, matchings and factors, bipartite matching and vertex cover, connectivity and paths, vertex coloring, edge colouring, edges and cycles, planar graphs, maximum flow, Gomory-Hu trees.
7	Contents for lab (If applicable)	<ol style="list-style-type: none"> 1. C. Papadimitriou and K. Steiglitz, Combinatorial optimization: algorithms and complexity, 2nd Edn., Dover, 1998) 2. A. Schrijver, Combinatorial Optimization, Springer-Verlag, 2002. 3. R. J. Wilson, Introduction to Graph Theory, Longman, 1985. 4. D. B.
8	List of text books/references	

1	Code of the subject	CS021
2	Title of the subject	Network Design and Optimization
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	To study optimization techniques for use in the domain of computer networks.

		To analyse network infrastructure requirements and to design and implement the infrastructure for business solutions.
6	Brief Contents	<p>Module 1: Introduction Graphs and Flows -Network Flow Models -Network Flow Algorithms - Shortest Path Problems - Label Setting (Dijkstra) Methods - Label Correcting Methods - Single Origin/Single Destination Methods - Auction Algorithms - Multiple Origin/Multiple Destination Methods</p> <p>Module 2: Max-Flow and Min-Cost Flow Problem Max-Flow and Min-Cut Problems - Ford-Fulkerson Algorithm - Price-Based Augmenting Path Algorithms - Transformations and Equivalences - Duality</p> <p>Module 3: Simplex Methods for Min-Cost Flow Main Ideas in Simplex Methods - Basic Simplex Algorithm - Extension to Problems with Upper and Lower Bounds - Implementation Issues</p> <p>Module 4: Dual Ascent Methods for Min-Cost Flow Dual Ascent -The Primal-Dual (Sequential Shortest Path) Method -The Relaxation Method -Sensitivity Analysis - Implementation Issues</p> <p>Module 5: Auction Algorithms for Min-Cost Flow The Auction Algorithm for the Assignment Problem - Extensions of the Auction Algorithm -The Preflow-Push Algorithm for Max-Flow -The Relaxation Method - The Auction/Sequential Shortest Path Algorithm - Nonlinear Network Optimization - Convex Separable Network Problems - Network Problems with Integer Constraints</p>
7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. —Network Optimization: Continuous and Discrete Methods , Dimitri Bertsekas, 1998. 2. —Network Flows: Theory, Algorithms, and Applications , James B. Orlin, Ravindra K. Ahuja, and Thomas L. Magnanti, 1993. 3. —Network Optimization Problems: Algorithms, Applications And Complexity , Panos M. Pardalos, Ding-Zhu Du, 1993. 4. —Routing, Flow and Capacity Designing in Communication and Computer Networks , M. Pioro and D. Medhi, Morgan Kaufmann, 2004.

1	Code of the subject	CS022
2	Title of the subject	Software reliability
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<ol style="list-style-type: none"> 1. Develop reliable software systems. 2. Understand the fault handling and failure forecasting techniques in software systems. 3. Understand different time dependent and time independent software reliability models. 4. Design reliability models for software systems.
6	Brief Contents	<p>Basic Ideas of Software Reliability, Hardware reliability vs. Software reliability, Reliability metrics, Failure and Faults – Prevention, Removal, Tolerance, Forecast, Dependability Concept – Failure Behaviour, Characteristics, Maintenance Policy, Reliability and Availability Modeling, Reliability Evaluation Testing methods, Limits, Starvation, Coverage, Filtering, Microscopic Model of Software Risk.</p> <p>Computation of software reliability, Functional and Operational Profile, Operational Profiles – Difficulties, Customer Type, User Type, System Mode, Test Selection - Selecting Operations, Regression Test.</p> <p>Classes of software reliability Models, Time Dependent Software Reliability Models: Time between failure reliability Models, Fault Counting Reliability Models. Time Independent Software Reliability Models: Fault injection model of Software Reliability, Input Domain Reliability Model, Orthogonal defect classification, Software availability Models. Software Reliability Modeling: A general procedure for reliability modeling. Short and Long Term Prediction, Model Accuracy, Analysing Predictive Accuracy – Outcomes, PLR, U and Y Plot, Errors and Inaccuracy, Recalibration – Detecting Bias, Different Techniques, Power of Recalibration, Limitations in Present Techniques, Improvements.</p>
7	Contents for lab (If applicable)	

8	List of text books/references	<p>1. J.D. Musa, Software Reliability Engineering, McGraw Hill, New York, 2004.</p> <p>2. H. Pham, Software Reliability, Springer Verlag, New York, 2000.</p> <p>3. Patric D. T.O Connor, Practical Reliability Engineering, 4th Edition, John Wesley & Sons, 2003.</p> <p>4. D. Reled, Software Reliability Methods, Springer Verlag, New York, 2001.</p>
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1	Code of the subject	CS023
2	Title of the subject	Computer Vision
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<p>Computer Vision focuses on development of algorithms and techniques to analyze and interpret the visible world around us. This requires understanding of the fundamental concepts related to multi-dimensional signal processing, feature extraction, pattern analysis visual geometric modeling, stochastic optimization etc. Applications range from Biometrics, Medical diagnosis, document processing, mining of visual content, to surveillance, advanced rendering.</p>
6	Brief Contents	<ol style="list-style-type: none"> 1. Fundamentals of Computer Vision, Affine and Projective Transformation 2. Convolution and Filtering, Image Enhancement, Histogram Processing, 3. Image Segmentation, Region Growing, Edge Based approaches to segmentation, Graph-Cut, Texture Segmentation 4. Object detection, Filters, edge detection techniques, Caney, Sobel, Prewitt 5. K-Means, K-Medoids Clustering, Optical Flow, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation. 6. Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation
7	Contents for lab (If applicable)	

8	List of text books/references	<p>1. Digital Image Processing, 3rd Edition Rafael C. Gonzalez, University of Tennessee, Richard E. Woods, Med Data Interactive</p> <p>2. Computer Vision: A Modern Approach; D. A. Forsyth and J. Ponce; Pearson Education; 2003.</p> <p>3. Computer Vision: Algorithms and Applications by Richard Szeliski; Springer-Verlag London Limited 2011.</p>
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1	Code of the subject	CS024
2	Title of the subject	Recommender Systems
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<p>1. To develop state-of-the-art recommender systems that automate a variety of choice-making strategies with the goal of providing affordable, personal, and high-quality recommendations.</p> <p>2. Discuss how recommender systems and user models are deployed in e-commerce sites and social networks.</p>
6	Brief Contents	<p>Introduction: Recommender system functions, Linear Algebra notation: Matrix addition, Multiplication, transposition, and inverses; covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system.</p> <p>Collaborative Filtering: User-based nearest neighbour recommendation, Item-based nearest neighbour recommendation, Model based and pre-processing based approaches, Attacks on collaborative recommender systems.</p> <p>Content-based recommendation: High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item profiles, discovering features of documents, obtaining item features from tags, Representing item profiles, Methods for learning user profiles, Similarity based retrieval, Classification algorithms.</p> <p>Knowledge based recommendation: Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders.</p> <p>Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design:</p>

		<p>Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies.</p> <p>Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs, Evaluation on historical datasets, Error metrics, Decision-Support metrics, User-Centred metrics.</p> <p>Recommender Systems and communities: Communities, collaboration and recommender systems in personalized web search, Social tagging recommender systems, Trust and recommendations, Group recommender systems.</p>
7	Contents for lab (If applicable)	Implementation of algorithms and techniques using relevant tools or high-level language.
8	List of text books/references	<ol style="list-style-type: none"> 1. Dietmar Jannach, Markus Zanker, Alexander Felfernig, Gerhard Friedrich, "Recommender Systems: An Introduction", Cambridge University Press (2011). 2. Francesco Ricci, Lior Rokach, Bracha Shapira, Paul B. Kantor, "Recommender Systems Handbook", Springer (2011). 3. Nikos Manouselis, Hendrik Drachsler, Katrien Verbert, Erik Duval, "Recommender Systems for Learning", Springer (2013).

1	Code of the subject	CS025
2	Title of the subject	Modern Cryptography
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<p>To make the students understand the process of deciphering coded messages without being told the key.</p> <p>To study of codes and the art of writing and solving them.</p> <p>To give motivation towards recent research development in the field of cryptography, cryptanalysis, and steganography.</p> <p>Overall this course explores modern cryptographic (code making) and cryptanalytic (code breaking) techniques in detail.</p>

6	Brief Contents	Number Theory Basics Modular arithmetic Fields, Binary Fields Primes, GCD and Chinese remainder theorems Extended Euclidean Algorithm and application Fermat's Little Theorem and application Euler Phi function, Block Ciphers in Mathematical way, DES Historical Ciphers (at least 7) Public Key Cryptography, RSA, Two fish.
7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. "Cryptography: Theory and Practice", Third Edition, by Douglas R. Stinson, CRC Press, Taylor and Francis Group. 2. "Handbook of Applied Cryptography", Fifth Printing, by Alfred J. Menezes, Paul C. van Oorschot, and Scott A. Vanstone, CRC Press. 3. "Cryptography and Network Security: Principles and Practices", Sixth Edition, by William Stallings. 4. —The Code Book- The secret history of Codes & Code-breaking by Simon Singh.

1	Code of the subject	CS026
2	Title of the subject	Robot Motion Planning
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	To study algorithms that reason about the movement of physical or virtual entities, To generate sequences of motions for many kinds of robots, robot teams, animated characters, and even molecules.
6	Brief Contents	<p>Module 1: An overview of robot motion planning problems.</p> <p>Module 2: Review of basic kinematics of rigid body motion. The configuration space of a rigid body. The classical motion planning paradigms: – the roadmap, the potential field method, – the cellular decomposition and approximate cellular decomposition approaches</p> <p>Module 3: Graph search and discrete planning algorithms. Sensor-Based Motion Planning Algorithms- the “Bug” algorithms - the TangentBug algorithm - the incremental Voronoi Graph - the D* algorithm</p> <p>Module 4: Potential field based methods, wave front planners. Non-holonomic systems and planning with kinematic constraints.</p> <p>Module 5: Motion planning for Multi robotic systems, motion planning in 3D</p>
7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. Planning Algorithms by Steve LaValle (Cambridge Univ. Press, New York, 2006). 2. Principles of Robot Motion: Theory, Algorithms, and Implementations (by Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun). 3. Probabilistic Robotics (by Sebastian Thrun, Wolfram Burgard, and Dieter Fox Lynch). MIT Press, 2005. 4. Robot Motion Planning by J.C. Latombe.

1	Code of the subject	CS027
2	Title of the subject	Nature Inspired Computing
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<p>It introduces a new paradigm of computing and solving problems.</p> <p>It has great applications in Artificial Intelligence, Data Mining, Machine Learning, and real-world design and optimization problems.</p>
6	Brief Contents	<p>Module I: Introduction: Introduction: Nature-inspired Computing, Evolutionary Computation, Swarm Intelligence, Artificial Neural Networks, Fuzzy Systems; Brief History.</p> <p>Module II: Evolutionary and Swarm Computing: Introduction to Evolutionary Computation: Representation, Initial Population, Fitness Function, Selection, Reproduction Operators, Stopping Conditions, Evolutionary versus Classical Computation; Genetic Algorithm: Canonical Genetic Algorithm, Crossover, Mutation, Control Parameters, Genetic Algorithm Variants, Applications; Differential Evolution: Basic Differential Evolution, Variants of Basic Differential Evolution, Differential Evolution for Discrete-valued Problems; Particle Swarm Optimization: Basic Particle Swarm Optimization, Social Network Structures, Basic Variants, Basic PSO Parameters, Applications; Artificial Bee Colony Algorithm: Basic ABC, Basic Variants, Basic ABC Parameters, Applications.</p> <p>Module III: Artificial Neural network: Introduction: Fundamental Concepts, Evolution, Basic Models, Terminology, McCulloch-Pitts Neuron, Linear Separability, Hebb Network; Supervised Learning Network: Perceptron Networks, Adaptive Linear Neuron, Multiple Adaptive Linear Neuron, Back-Propagation Network, Radial Basis Function Network; Associative Memory Network: Training Algorithms for Pattern Association, Associative Memory Network, Heteroassociative Memory Network, Bidirectional Associative Memory, Hopfield Network, Iterative Autoassociative Memory Network, Temporal Associative Memory Network; Unsupervised Learning Networks: Fixed Weight</p>

		Competitive Nets, Kohonen Self-Organizing Feature Map, Linear Vector Quantization, Counter Propagation Network, Adaptive Resonance Theory Network. Module IV: Fuzzy Logic and Fuzzy Sets: Introduction to Classical Sets and Fuzzy Sets: Classical Sets, Fuzzy Sets; Classical Relations and Fuzzy Relations: Classical Relation, Fuzzy Relations, Tolerance and Equivalence Relations, Noninteractive Fuzzy Sets; Membership Functions; Defuzzification; Fuzzy Arithmetic and Fuzzy Measures; Fuzzy Rule Base and Approximate Reasoning; Fuzzy Decision Making.
7	Contents for lab (If applicable)	
8	List of text books/references	<ol style="list-style-type: none"> 1. Principles of Soft Computing, S N Sivanandam and S N Deepa, Wiley 2. Computational Intelligence: An Introduction, Andries P. Engelbrecht, John Wiley & Sons. 3. Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications, S. Rajasekaran and G. A. VijayalakshmiPai, PHI.

1	Code of the subject	CS028
2	Title of the subject	Game Theory and Applications
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	<ol style="list-style-type: none"> 1. Understanding the basic game theory concepts, including utility, strategies, and Nash equilibrium. 2. Knowledge of advanced game theory concepts, such as repeated games, signalling games, and mechanism design. 3. Understanding the limitations of game theory and its relationship to other decision-making frameworks. 4. Developing critical thinking skills and the ability to apply game theory to evaluate and design strategies in different domains.

		5. Knowledge of the use of game theory in various fields, such as economics, political science, and computer science.
6	Brief Contents	Introduction to Game Theory, Dominant Strategies and Nash Equilibrium, Alternate Strategies: Maximin, Maximax, and Minimax Regret Solvability, N-Player Games, Mixed Strategy Nash Equilibria, Subgame Perfection in Discrete Choice Games, Continuous Games and Imperfect Competition, Infinitely Repeated Games, Tacit Collusion: An application of Infinites Repeated Games, imperfect Information: Simultaneous-play, ayesian Games, Applications of Bayesian Games: Auctions and Voting, Cournot's Duopoly with Imperfect Information 3. Radio Spectrum, With Arbitrary Distribution of Valuations, Extensive Form Game with Perfect Information, Stackelberg Model of Duopoly, Buying Votes, Committee Decision Making, Repeated games, The Prisoner's Dilemma, General Result, Supermodular Game and Potential Game, Supermodular Game and Potential Game, Wireless Networks: Resource Allocations, Admission Control, Routing in Sensor and AdHoc Networks, Modeling Network Traffic and Strategic Network Formation, Rubinstein Bargaining Model with Alternating Offers, Nash Bargaining Solution, Relation of Axiomatic and Strategic Model, Auction and Mechanism Design with Applications, Revenue Equivalence, Risk Averse Bidders, Asymmetries among Bidders, Mechanism, Optimal Mechanism
7	List of text books/references	<ol style="list-style-type: none"> 1. Nisan Roughgarden, Tardos, Vazirani (eds), Algorithmic Game Theory, Cambridge University, 2007 2. Maschler, Michael, Shmuel Zamir, and Eilon Solan. Game theory. Cambridge University Press, 2020. 3. Narahari, Yadati. Game theory and mechanism design. Vol. 4. World Scientific, 2014.

1	Code of the subject	CS029
2	Title of the subject	Human - Computer Interaction
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	The topics covered in the course includes the engineering life cycles for design of interactive systems, computational design framework (as part of the life cycle), components of the framework including the computational models of users and systems, and evaluation of such systems (with or without users).
6	Brief Contents	<p>Module 1: Introduction to user-centric design – case studies, historical evolution, issues and challenges and current trend, Engineering user-centric systems – relation with software engineering, iterative life-cycle, prototyping, guidelines, case studies</p> <p>Module 2: User-centric computing – framework, introduction to models, model taxonomy, Computational user models (classical) – GOMS, KLM, Fitts’ law, Hick-Hymans law</p> <p>Module 3: Computational user models (contemporary) 2D and 3D pointing, constrained navigation, mobile typing, touch interaction, Formal models – case study with matrix algebra, specification and verification of properties, formal dialog modeling</p> <p>Module 4: Empirical research – research question formulation, experiment design, data analysis, statistical significance test</p> <p>Module 5: User-centric design evaluation – overview of evaluation techniques, expert evaluation, user evaluation, model-based evaluation with case studies</p>
7	Contents for lab (If applicable)	1. Bhattacharya, S. (July, 2019). Human-Computer Interaction: User-Centric Computing for Design, McGraw-Hill India, Print Edition
8	List of text books/references	

1	Code of the subject	CS030
2	Title of the subject	Randomized Algorithms
3	Any prerequisite	
4	L-T-P	3-0-0
5	Learning Objectives of the subject (in about 50 words)	To use discrete probability theory to describe and model randomized processes and algorithms, to use discrete probability to analyze the performance of deterministic and randomized algorithms, to design randomized algorithms that solve computational problems of moderate difficulty, to know several standard tail inequalities (Markov inequality, Chebyshev inequality, Chernoff bound) and be able to apply them to analyze performance of randomized algorithms.
6	Brief Contents	Random numbers: Properties of a random sequence. Generating uniform random numbers: the linear congruential method and others. Statistical tests for random numbers: Chi-square test, Kolmogorov-Smirnov test, empirical / theoretical / spectral tests. Non-uniform random sequences. Tools and techniques of randomized algorithms: game theoretic techniques, moments and deviations, tail inequalities, the probabilistic method: Lovasz Local Lemma, Markov chains and random walks, algebraic techniques. Applications: Data structures, hashing, linear programming, computational geometry problems, graph problems, approximate algorithms, parallel and distributed algorithms, cryptography, online algorithms. Derandomization techniques.
7	Contents for lab (If applicable)	<ol style="list-style-type: none"> 1. R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press, 1995. 2. D. E. Knuth, The Art of Computer Programming, 3rd Ed, Vol 2, Seminumerical Algorithms, Addison-Wesley, 1998. 3. W. Feller, An Introduction to Probability Theo
8	List of text books/references	