Curriculum & Contents

B Tech (CSE)

विश्वजीवनामृतं ज्ञानम्

ABV-Indian Institute of Information Technology & Management, Gwalior

June 2019

Subjects List

Semester I				
S. No.	**Subject Code**	**Title of the course**	**L-T-P**	**Credits**
1.	BCAS-1101	Engineering Physics	3-0-0	3
2.	BCAS-1102	Mathematics-I	3-1-0	4
3.	BCCS-1101	Computer Programming: Concepts and Practice	3-0-0	3
4.	BCCS-1102	Foundations of Computer Science	2-0-2	3
5.	BCHS-1101	Communication Skills	2-0-0	2
6.	BCHS-1102	Ethics and Human Values	2-0-0	2
7.	BCAS-1103	Engineering Physics Lab	0-0-2	1
8.	BCCS-1103	Computer Programming Lab	0-0-4	2
9.	BCHS-1103	Communication Skills Lab	0-0-2	1
10.	BCHS-1105	Sports and Physical Education	1-0-2	2
		Total Credits		**23**

Semester II				
S. No.	**Subject Code**	**Title of the course**	**L-T-P**	**Credits**
1.	BCAS-1201	Mathematics-II	3-1-0	4
2.	BCCS-1201	Data Structures	3-0-0	3
3.	BCCS-1202	Data Base Systems	3-0-0	3
4.	BCAS-1202	Discrete Mathematical Structures	2-1-0	3
5.	BCCS-1203	Digital Circuits System	3-0-0	3
6.	BCHS-1201	Principles and Practices of Management	3-0-0	3
7.	BCCS-1204	Data Structures Lab	0-0-2	1
8.	BCCS-1205	Digital Circuits System Lab	0-0-2	1
9.	BCCS-1206	Data Base Systems Lab	0-0-2	1
		Total Credits		**22**

Semester III				
S. No.	**Subject Code**	**Title of the course**	**L-T-P**	**Credits**
1.	BCAS-2101	Probability and Statistics	3-0-0	3
2.	BCCS-2101	Analysis and Design of Algorithms	3-0-0	3
3.	BCCS-2102	Computer Organization and Architecture	3-0-0	3
4.	BCCS-2103	Operating System	3-0-0	3
5.	BCCS-2104	Object Oriented Programming Language	3-0-0	3
6.	BCHS-2101	Environmental Sciences	2-0-0	2
7.	BCCS-2105	Analysis and Design of Algorithms Lab	0-0-2	1
8.	BCCS-2106	Operating System Lab	0-0-2	1
9.	BCCS-2107	Object Oriented Programming Language Lab	0-0-2	1
		Total Credits		**20**

Semester IV				
S. No.	**Subject Code**	**Title of the course**	**L-T-P**	**Credits**
1.	BCCS-2201	Theory of Computation	3-0-0	3
2.	BCCS-2202	Artificial Intelligence	3-0-0	3
3.	BCCS-2203	Computer Network*	3-0-0	3
4.	BCCS-2204	Software Engineering	3-0-0	3
5.		Elective-I	3-0-0	3
6.		Elective-II	3-0-0	3
7.	BCCS-2205	Artificial Intelligence Lab	0-0-2	1
8.	BCCS-2206	Computer Network Lab	0-0-2	1
9.	BCCS-2207	Software Engineering Lab	0-0-2	1
		Total Credits		**21**

**Syllabus of computer network will comprise of concepts of data communication and computer networks*

S. No.	**Subject Code**	**Course**	**L-T- P**	**Credits**
1.	BCCS-2999	Minor Project (Summer Project)	0-0-6	**3**

Semester V				
S. No.	**Subject code**	**Title of the course**	**L-T-P**	**Credits**
1.	BCCS-3101	Computer Graphics	3-0-0	3
2.	BCCS-3102	Data Mining and Data Warehouse	3-0-0	3
3.	BCCS-3103	Information Security Systems	3-0-0	3
4.	BCCS-3104	Compiler Design	3-0-0	3
5.		Elective-I	3-0-0	3
6.		Elective-II	3-0-0	3
7.	BCCS-3105	Computer Graphics Lab	0-0-2	1
8.	BCCS-3106	Systems Software Lab	0-0-2	1
		Total Credits		**20**

Semester VI				
S. No.	**Subject Code**	**Title of the course**	**L-T-P**	**Credits**
1.	BCCS-3201	Graph Theory	3-0-0	3
2.	BCCS-3202	Machine Learning	3-0-0	3
3.	BCCS-3203	Cloud Computing	3-0-0	3
4.		Elective-I	3-0-0	3
5.		Elective-II	3-0-0	3
6.		Elective-III	3-0-0	3
7.	BCCS-3204	Machine Learning Lab	0-0-2	1
8.	BCCS-3205	Cloud Computing Lab	0-0-2	1
		Total Credits		**20**

Industrial Training: Students to undertake summer internships during summer break (May to July)

Semester VII				
S. No.	**Subject Code**	**Title of the course**	**L-T-P**	**Credits**
1.	BCCS-4101	Modeling and Simulation	3-0-0	3
2.	BCCS-4102	Big Data Analytics	3-0-0	3
3.	BCCS-4103	Fundamentals of Internet of Things	3-0-0	3
4.		Elective-I	3-0-0	3
5.		Elective-II	3-0-0	3
6.		Elective-III	3-0-0	3
7.	BCCS-4104	Simulation Lab	0-0-2	1
8.	BCCS-4105	Colloquium	0-0-4	2
		Total Credits		**21**

Semester VIII				
S. No.	**Subject Code**	**Title of the course**	**L-T-P**	**Credits**
1.	BCCS-4999	Major Project	0-0-30	15
2.		Elective-I	3-0-0	3
		Total Credits		**18**

Electives (Semester wise)

The electives are arranged sequentially from 4th Semester to 8th Semester from seven verticals, namely,

1. Computing and Data Sciences
2. Networks and Distributed Processing
3. Security
4. AI and Robotics
5. Visual Information Processing
6. VLSI and Nanotechnology
7. Computer Architecture and System Design

Categories of Electives

1. **Computing and Data Sciences**

S. No.	Subject Code	Title of the course	L-T-P	Credits
1.	**BCCS-9101**	Convex Optimization Techniques	2-1-0	3
2.	**BCCS-9102**	Quantum Computing	3-0-0	3
3.	**BCCS-9103**	Complexity and Advanced Algorithm	3-0-0	3
4.	**BCCS-9104**	Reconfigurable Computing	3-0-0	3
5.	**BCCS-9105**	Parallel & Concurrent Programming	2-0-2	3
6.	**BCCS-9106**	Program Analysis Verification and Testing	3-0-0	3
7.	**BCCS-9107**	Randomized Algorithms	3-0-0	3
8.	**BCCS-9108**	Semantics of Programming Languages	3-0-0	3
9.	**BCCS-9109**	Game Theory	2-1-0	3
10.	**BCCS-9110**	Scientific Computing and Numerical Methods	2-1-0	3
11.	**BCCS-9111**	Advanced Competitive Programming	1-0-4	3
12.	**BCCS-9112**	Big Data and Cloud Computing	3-0-0	3
13.	**BCCS-9113**	Data Analytics	3-0-0	3

2. Networks and Distributed Processing

S.No.	Subject Code	Title of the course	L-T-P	Credits
1.	**BCCS-9201**	Queuing Theory and Data Networks	3-0-0	3
2.	**BCCS-9202**	High Speed Networks/Internet Traffic -Measurement, Modelling and Analysis	3-0-0	3
3.	**BCCS-9203**	Cellular and Mobile Communication Systems	3-0-0	3
4.	**BCCS-9204**	Wireless Sensor Networks	3-0-0	3
5.	**BCCS-9205**	Special Topics in Complex Networks	3-0-0	3
6.	**BCCS-9206**	Parallel and Distributed Computing	3-0-0	3
7.	**BCCS-9207**	Grid and Peer-to-Peer Computing	3-0-0	3
8.	**BCCS-9208**	Special Topics in Internet Technologies	3-0-0	3
9.	**BCCS-9209**	Next Generation Networks	3-0-0	3
10.	**BCCS-9210**	Cognitive Network	3-0-0	3
11.	**BCCS-9211**	Information Theory and Coding	3-0-0	3
12.	**BCCS-9212**	Detection and Estimation Theory	3-0-0	3

3.Security

S. No.	Subject Code	Title of the course	L-T-P	Credits
1.	**BCCS-9301**	Computer Security Audit and Assurance	3-0-0	3
2.	**BCCS-9302**	Cryptography and Network Security	3-0-0	3
3.	**BCCS-9303**	Computer Systems Security	3-0-0	3
4.	**BCCS-9304**	Web Architecture Security	3-0-0	3
5.	**BCCS-9305**	Cyber Security and Laws	3-0-0	3
6.	**BCCS-9306**	Malware Analysis	3-0-0	3
7.	**BCCS-9307**	IoT and its Security	3-0-0	3
8.	**BCCS-9308**	Formal methods for Security Verifications	3-0-0	3
9.	**BCCS-9309**	Modern Cryptology	3-0-0	3
10.	**BCCS-9310**	Specialized Course in cryptography	3-0-0	3
11.	**BCCS-9311**	Information Security and Secure Coding	3-0-0	3
12.	**BCCS-9312**	Digital Watermarking &Steganalysis	3-0-0	3

4.AI& Robotics

S. No.	Subject Code	Title of the course	L-T-P	Credits
1.	**BCCS-9401**	Microelectronics	3-0-0	3
2.	**BCCS-9402**	Introduction to Robotics	3-0-0	3
3.	**BCCS-9403**	Embedded Robotics	3-0-0	3
4.	**BCCS-9404**	Mobile Robotics	3-0-0	3
5.	**BCCS-9405**	Introduction to Cognitive Science	3-0-0	3
6.	**BCCS-9406**	Decision Making and Expert system	3-0-0	3
7.	**BCCS-9407**	Nature Inspired computing	3-0-0	3
8.	**BCCS-9408**	Intelligent Systems and Interfaces	3-0-0	3
9.	**BCCS-9409**	System Biology	3-0-0	3
10.	**BCCS-9410**	Multi Agents and Application	3-0-0	3
11.	**BCCS-9411**	Special topics in AI	3-0-0	3

5.Visual Information Processing

S. No.	Subject Code	Title of the course	L-T-P	Credits
1.	**BCCS-9501**	Information Retrieval and Extraction	3-0-0	3
2.	**BCCS-9502**	Image Processing	3-0-0	3
3.	**BCCS-9503**	Digital Watermarking &Steganalysis	3-0-0	3
4.	**BCCS-9504**	Pattern Recognition	3-0-0	3
5.	**BCCS-9505**	Multimedia Systems	3-0-0	3
6.	**BCCS-9506**	Human Computer Interaction	3-0-0	3
7.	**BCCS-9507**	Computer Vision	3-0-0	3
8.	**BCCS-9508**	Digital Signal Processing	3-0-0	3

6.VLSI& Nanotechnology

S.No.	Subject Code	Title of the course	L-T-P	Credits
1.	**BCCS-9601**	Introduction to Nanoscience and Technology	3-0-0	3
2.	**BCCS-9602**	VLSI Design	3-0-0	3
3.	**BCCS-9603**	VLSI Testing and Fault Tolerance	3-0-0	3
4.	**BCCS-9604**	CAD for VLSI	3-0-0	3
5.	**BCCS-9605**	Nano electronics	3-0-0	3
6.	**BCCS-9606**	Synthesis of Digital Systems	3-0-0	3
7.	**BCCS-9607**	Integrated Circuit Technology	3-0-0	3
8.	**BCCS-9608**	Memory Design	3-0-0	3
9.	**BCCS-9609**	Low Power VLSI Design	3-0-0	3
10.	**BCCS-9610**	Energy Aware Computing	3-0-0	3
11.	**BCCS-9611**	Molecular Nanoelectronics	3-0-0	3

7. Computer Architecture and System Design

S.No.	Subject Code	Title of the course	L-T-P	Credits
1.	**BCCS-9701**	Advanced Computer Architecture	3-0-0	3
2.	**BCCS-9702**	Cyber Physical System Design	3-0-0	3
3.	**BCCS-9703**	System-on-Chip Design	3-0-0	3
4.	**BCCS-9704**	On-Chip Interconnection Networks	3-0-0	3
5.	**BCCS-9705**	Trustworthy Systems Design	3-0-0	3
6.	**BCCS-9706**	Neurocomputing Architectures/High Performance Computing	3-0-0	3
7.	**BCCS-9707**	Advanced Compiler Design	3-0-0	3

Please note:

a) The course contents are indicative in nature. Actual contents followed may deviate based on students/faculty interests.

b) Typically the evaluation is based on various components such as Minors (In-semester tests), Major examination (End-semester test), assignments, term papers, quizzes, presentations and class participation. The weightages for these components will be decided by the respective course instructors.

Semester-I

1	**Code of the subject**	BCAS-1101
2	**Title of the subject**	Engineering Physics
3	**Any prerequisite**	Basic concepts of Fundamental of Physics and Physical Chemistry
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Pankaj Srivastava and Anurag Srivastava
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	• The course has been designed in such a way so that a Computer Science graduate can understand the fundamental concepts of physics and chemistry of materials. • Besides the basic concepts, how it is useful in variety of possible applications. • There are few topics of future interest too, like lasers, fiber optics and 1D/2D materials, especially the wonder material grapheme. • There lot many opportunity for those who are interested in making their career as researcher in the area of scientific computing and IoT projects.
8	**Brief Contents (module wise)**	***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, wave propagation in bounded system, applications. ***Quantum Physics***: Dual nature of matter, de-Broglie Hypothesis, Heisenberg uncertainty principle and its applications, postulates of quantum mechanics, wave function & its physical significance, probability density, Schrodinger's wave equation, eigenvalues &eigen functions, Appl. of Schroedinger equation. ***Physics of Materials***: Crystal structure, crystal systems, energy bands in solids, Brillouin zones, classification of solids, conductivity in metals and concepts of Fermi level, effective mass and holes, concept of phonons, electron distribution function, Fermi-Dirac distribution function, properties of bulk materials and nanomaterials. Synthesis and characterization techniques. Carbon materials, Graphene and 2D materials and its applications. ***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.
9	**Contents for lab**	NA
10	**List of text books/references**	• Panofsky & Phillips, *Classical Electricity & Magnetism*, 2nd ed., Dover Publications, 2005. (Text Book). • David J Griffith, *Introduction to Quantum Mechanics,2*nd ed. , PHI, 2013. (Text Book). • Avadhanulu, M. N, &Kshirsagar, S. G., *A Textbook of Engineering Physics*, S. Chand, 2014. (Text Book) • Neeraj Mehta, *Applied Physics for Engineers*, PHI Learning Pvt. Ltd., 2011. (Text Book) • Fiber optic communication- J Keiser (McGraw Hill) (Text Book) • David J Griffith, *Introduction to Electrodynamics*, 4th ed. , PHI, 2014. (Ref.). • Paul Dirac, *Principles of Quantum Mechanics*, 4th ed., Oxford Uni. Press, 2004. (Ref.) • Kittel, C., *Introduction to Solid State Physics*, 8th ed., Wiley, 2014. (Ref.) • Ohring, M., *Engineering Material Science*, Academic Press, 1995. (Ref.)

1	**Code of the subject**	BCAS-1102
2	**Title of the subject**	Mathematics-I
3	**Any prerequisite**	Basic Algebra and Calculus
4	**L-T-P**	3-1-0
5	**Name of the proposer**	Dr. JoydipDhar
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ Ability to comprehend mathematical principles and logic ➢ Ability to manipulate and analyzing data numerically and/or graphically using appropriate software ➢ Ability to solve real life problems, translating them one form to another, using appropriate mathematical and computational techniques ➢ Understanding of theoretical concepts and limits of computing
8	**Brief Contents (module wise)**	**Module I: Linear Algebra-I:** Systems of linear equations, Row reduction and echelon forms, Rank, Eigenvalues and eigenvectors, Diagonalization of a matrix, Block matrices, Linear dependence and independence **Module II: Linear Algebra-II:** Vector space, Subspaces and bases and dimensions, Orthogonal bases and orthogonal projections, Gram-Schmidt process, Symmetric matrices, Positive definite matrices, Similar matrices, Linear transformations, Cannonical Form, Jordan Form, Inner Product Space, Spectral Theory, Singular Value Decomposition **Module III: Calculus:** Multiple Integrals (Double Integrals, Triple Integrals), Functions of several variables: Partial derivatives and its applications, Taylor series, Maxima–minima of several variables, Error and approximation **Module IV: Ordinary Differential Equations:** First order differential equations – exact and reducible to exact form. Linear differential equations of higher order with constant coefficients, Variation of parameters, Solution of homogeneous differential equations, Non-homogeneous differential equations, Cauchy and Legendre forms, Orthogonal trajectories **Module V: Partial Differential Equations:** Formation of PDE,Solution of Langrage's Linear equation. Nonlinear equations - Charpit method, Homogeneous PDE with constant coefficients, Applications: Solution by separation of variables, One dimensional Wave and Heat equations (Derivation and solutions by separation of variables), Steady state condition in one dimensional heat equation, Boundary Value problems in one dimensional Wave and Heat Equations
9	**Contents for lab**	NIL
10	**List of text books/references**	1. K. Hoffman, R. A. Kunze, Linear Algebra, PHI Learning, 2014 2. E. Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2011 3. Thomas and Finney, Calculas, Pearson Education, 2010 4. R. K. Jain and S. R. K Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2012

1	**Code of the subject**	BCCS-1101
2	**Title of the subject**	Computer Programming: Concepts and Practice
3	**Any prerequisite**	Mathematics
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr Saumya Bhadauria
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	• 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.
8	**Brief Contents (module wise)**	**Module I:** Basics of Computer Languages C, Compilers, Interpreter, Programming Environments and Debugging: types of errors and debugging techniques. **Module II:** Programming features: Data types, Expressions and Operators, Control statements, Iterations. **Module III:** Functions: Scope of variables, call by value, call by reference, Recursion, Pointers. **Module IV:** Array, String, Structures and Unions. **Module V:** File handling, File redirection, File pointers. **Module VI:** Applications of C programming concepts in different data structures. **Module VII:** Python: Introduction, Program Organization, Functions, Modules and Libraries.
9	**Contents for lab**	Mentioned in the **Lab** Course
10	**List of text books/references**	• Kernighan, B.W. and D. M. Ritchie (1998): The C programming language, 2nd ed. Prentice Hall of India. • Kanetkar, Y (2016): Let us C, 15th ed .BPB Publications. • King K.N (2008): C Programming: A Modern Approach. 2nd ed. W. W. Norton & Company.

1	**Code of the subject**	BCCS-1102
2	**Title of the subject**	Foundations of Computer Science
3	**Any prerequisite**	No
4	**L-T-P**	2-0-2
5	**Name of the proposer**	Prof. Pramod Kumar Singh
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ Assimilation with basics and fundamental concepts of computer and computer science as a discipline. ➢ Assimilation of hardware components of computer and practical knowledge of programming in assembly language and high level language.
8	**Brief Contents (module wise)**	**Module I: Introduction, Data Storage, and Data Manipulation** Introduction; Brief History of Computing and Computers; Data Storage: Bits and Their Storage, Main Memory, Mass Storage, Representing Information as Bit Patterns; Data Manipulation: Computer Architecture, Machine Language, Program Execution. **Module II: Input and Output Devices** Input devices: keyboard, Mouse, Touch Pad, Touch Screen, MICR, OMR, Scanner, OCR, Bar code; Output devices: Display Unit, E-ink Display, Printers, Plotters. **Module III: Operating Systems** History; Architecture; Coordinating the Machine Activities, Handling Competition among processes. **Module IV: Networking and Internet** Network Fundamentals, Internet, World Wide Web, Internet protocols. **Module V: Algorithms** Basic Concepts, Representation, Discovery, Iterative Structures, Recursive Structures, Efficiency and Correctness. **Module VI: Programming Languages** Historical Perspective, Tradition Programming Concepts, Procedural Units, Language Implementation, Object-Oriented Programming. **Module VII: Software Engineering** Basics, Software Life Cycle, Software Engineering Methodologies, Modularity, Tools of the Trade, Quality Assurance, Documentation, Human-Machine Interface, Ownership and Liability. **Module VIII: Data Abstractions** Basic Data Structures, Related Concepts, Implementing Data Structures, Customized Data Types, Classes and Objects. **Module IX: Database Systems** Fundamentals, Relational Model, Data Mining, Social Impact of Database Technology. **Module X: Computer Graphics** Basics, Overview of 3D Graphics, Modeling, Rendering, Animation. **Module XI: Artificial Intelligence** Intelligence and Machines, Perception, Reasoning, Robotics, Additional Areas of research, Consequences.
9	**Contents for lab (If applicable)**	Assimilation with Hardware Components of Computer, Assembly and Disassembly of Computer, Programming in Assembly and Higher Level Language.
10	**List of text books/references**	1. Computer Science: An Overview, J. Glenn Brookshear, and Dennis Brylow, Pearson. 2. Fundamentals of Computers, V. Rajaraman, and NeeharikaAdabala, PHI.

1	**Code of the subject**	BCHS-1101
2	**Title of the subject**	Communication Skills
3	**Any prerequisite**	
4	**L-T-P**	2-0-0
5	**Name of the proposer**	Dr. Yash Daultani
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• To make students understand the importance and effective use of verbal and non-verbal communication • To make the learner proficient in public speaking and presentation skills • To guide students to utilize the principles of professional business and technical writing for effective communication in the global world • To make the learner capable of creating official content in today's world driven by digital and social media communication
8	**Brief Contents (module wise)**	• **Module I**— *Communication Theory*: Concept and Meaning, Communication cycle, Objectives, Barriers to communication (linguistic and semantic, psychological, physical, mechanical, cultural), Methods of communication (verbal and non-verbal), Networks of communication (formal and informal), Language skills (listening, speaking, reading, writing) • **Module II** — *Business Correspondence:* Principles of Business Correspondence, Parts of a business letter, Formats (Complete block and Modified block), Types of letters: Enquiry, Reply to enquiry, Claim, Adjustment and Sales letter • **Module III** — *Grammar and Vocabulary:* Common errors, Concord (subject-verb agreement), Pairs of confused words, Lexicon (Enriching vocabulary through one-word substitutes, synonyms, antonyms, etc.). Summarization and Comprehension, passages to test the analytical skills and expression • **Module IV**— *Technical writing :* Techniques to define an object, writing instructions, language exercises based on types of expositions (description of an object, explanation of a process) • **Module V** — *Information Communication Technology (ICT) enabled communication media*: E-mail, Blog and Website. Corporate communication: Digital Content Creation. Social media communication
9	**Contents for lab (If applicable)**	Mentioned in the Lab Course
10	**List of text books/references**	• Business Communication Essentials: Fundamental Skills for the Mobile-Digital-Social Workplace, 8th Edition by Bovee and Thill (Pearson) • Business Correspondence and Report Writing, 5th Edition by R C Sharma and Krishna Mohan (McGraw-Hill) • Essentials of Business Communication, 11th Edition by Guffey and Loewy (Cengage)

1	**Code of the subject**	BCHS-1102
2	**Title of the subject**	Ethics and Human Values
3	**Any prerequisite**	Nil
4	**L-T-P**	2-0-0
5	**Name of the proposer**	Prof. V.S.R. Krishnaiah
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	The primary objective of this course is to create awareness on Ethics and Human Values among the students and make them understand the relevance of these ideas in their day to day personal and professional lives. The course will also sensitize students on social responsibility of ICT professionals. It further aims to instill moral and social values as well as professional code of conduct in the computer science students to make them good quality professionals so as to perform their professional responsibilities better in their future career.
8	**Brief Contents (module wise)**	**Module-I:** Definitions of Ethics, Engineering Ethics, and Morality. Categorization of Ethics, Differentiation of Morality and Ethics, Ten personal ethical behaviors which are globally acceptable, Definition of virtues, Elaboration of cardinal virtues, Definition of human values, Shalome H Shwartz value classification with examples, Learning from Moral Insights of Great Epics like Ramayan and Mahabharat **Module-II:** Definition of Profession and Professional, Responsibilities of professionals, the objectives of any one professional association, ACM Code of Ethics and Professional Conduct, IEEE Code of Ethics **Module-III:** Significance of ethics in ICT sector, Global Ethical Issues in ICT Sector with examples, Definitions of CSR, The stakeholders and their expectations from an organization, The Company Act 2013, Benefits of CSR in organization, Examples of CSR in ICT sector **Module-IV:**Ethical Dilemmas, Main features of Whistle Blowing, Definition of Life Skills, Four Categories of Life Skills
9	**Contents for lab**	Not Applicable
10	**List of text books/references**	1.Professional Ethics by R.Subramanian, Oxford University Press, 2013 2. Professional Ethics and Human Values by R.S.Nagarazan, New Age International (P) Ltd,2006

1	**Code of the subject**	BCAS-1103
2	**Title of the subject**	Engineering Physics Lab
3	**Any prerequisite**	Fundamental Concepts of Physics as per the course content of 12^{th} Standard
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Pankaj Srivastava and Anurag Srivastava
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	• The experiments have been introduced to visualize the fundamental concepts of Physics. • Most of the experiments are based on the concepts, which have been taught during 12^{th} at a very basic level but by doing experiment they can visualize the concept. • Few experiments are being introduced to make the students aware about new concepts and tools of modern physics and very useful for the understanding the other subjects like in Materials science, Optics, Semiconductor physics, Magnetism and Communication electronics.
8	**Brief Contents (module wise)**	• Study of Hall Effect • Resistivity and band gap of semiconductor by Four Probe Setup • Frank Hertz Experiment • Solar Energy Trainer • e/m by magnetron valve • numerical aperture &loss measurement of a given Optical Fiber • Investigation of B-H Curve • Lattice Dynamic • Fiber Optic Trainer • Forbidden Energy band gap measurement • Dielectric Constant measurement • Laser Trainer • Plank's Constant using LED • Laser Beam Parameters
9	**Contents for lab (If applicable)**	Lab Test 1 (1 hr) 20% weightage Lab Test 2 (1hr) 20% weightage Assignments/projects 10% weightage Attendance 10% weightage Major Lab Test(2hr) 40% weightage
10	**List of text books/references**	• Practical Physics- G L Squires • A text book of practical physics-William Watson • Practical Physics- C L Arora • Text Book of practical Physics- M N Srinivasan • Engg. Physics Practical- Rao, Krishna, Rudramamba

1	**Code of the subject**	BCCS-1103
2	**Title of the subject**	Computer Programming Lab
3	**Any prerequisite**	Mathematics
4	**L-T-P**	0-0-4
5	**Name of the proposer**	Saumya Bhadauria
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	• To develop ability to write programs and map scientific problems into computational frameworks. • To utilize the concepts of programming in application development. • To able to design, test and debug the programs.
8	**Brief Contents (module wise)**	Module I: Programming with C: Fundamentals of C programming, Control statements Module II: C programming with Functions (call by value and call by reference), parameter passing Module III: Programming via Recursion, Pointers. Module IV: Implementation of Array, String, Structures and Unions. Module V: File handling, File redirection, File pointers in C and Python Module VI: Problem Solving
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	• Kernighan, B.W. and D. M. Ritchie (1998): The C programming language, 2nd ed. Prentice Hall of India. • Kanetkar, Y (2016): Let us C, 15th ed .BPB Publications. • King, K.N (2008): C Programming: A Modern Approach, 2nd ed. W. W. Norton & Company. • Chun, W. J (2009): Core Python Programming, 3rd ed. Prentice Hall PTR. • Zelle, J(2002): Python Programming: An Introduction to Computer Science, 2nd ed. Franklin, Beedle& Associates Inc.

1	**Code of the subject**	BCHS-1103
2	**Title of the subject**	Communication Skills Lab
3	**Any prerequisite**	
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Yash Daultani
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• To enable students to develop their communicative competence using ICT based software • To facilitate students to open up and communicate well in public settings • To foster team spirit and group communication
8	**Brief Contents**	
9	**Contents for lab (If applicable)**	The following contents will be covered by using ICT tools and world-class training and learning software available in Communication lab. Module I Listening and Speaking Skills Module II Reading and Writing Skills (including grammar) Module III English for National and International Examinations Module IV Soft Skills
10	**List of text books/references**	• Business Communication Essentials: Fundamental Skills for the Mobile-Digital-Social Workplace, 8th Edition by Bovee and Thill (Pearson) • Business Correspondence and Report Writing, 5th Edition by R C Sharma and Krishna Mohan (McGraw-Hill) • Essentials of Business Communication, 11th Edition by Guffey and Loewy (Cengage)

1	**Code of the subject**	BCHS-1105
2	**Title of the subject**	Sports and Physical Education
3	**Any prerequisite**	No
4	**L-T-P**	1-0-2
5	**Name of the proposer**	Anurag Srivastava
6	**Will this course require visiting faculty**	Yes ..Experts/players from different sports and related areas will conduct the sessions
7	**Learning Objectives of the subject (in about 50 words)**	• Students will get knowledge and understanding of the facts, concepts and practice relating to a range of sports-both indoor and outdoor. • This will teach the students how to keep them fit, to increase his/her concentration, team coordination ability, which will help them as a professional. • This course will help students getting healthy, smarter, social and stress free.
8	**Brief Contents (module wise)**	The course will be taught in two components a) 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
9	**Contents for Field**	Field Sessions Indoor/ Outdoor: Cricket/ Football/ Volleyball/ Basketball/ Badminton/ Table-Tennis/ Lawn-Tennis/ Athletics/ Yoga
10	**List of text books/references**	• 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

Semester-II

1	**Code of the subject**	BCAS-1201
2	**Title of the subject**	Mathematics-II
3	**Any prerequisite**	Mathematics-I
4	**L-T-P**	3-1-0
5	**Name of the proposer**	Anuraj Singh
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	➢ Ability to comprehend mathematical principles and logic ➢ Ability to manipulate and analyzing data numerically and/or graphically using appropriate software ➢ Ability to solve real life problems, translating them one form to another, using appropriate mathematical and computational techniques ➢ Understanding of theoretical concepts and limits of computing
8	**Brief Contents (module wise)**	**Module-I** Laplace transform and Its properties, Laplace transform of Unit Step and Dirac-Delta functions, Laplace transform of periodic functions, Laplace transform for differentiation and integration, Inverse Laplace transform,Convolution theorem, Application of Laplace transform to solution of linear differential equations **Module-II** Introduction of Fourier series, Half range Sine and Cosine series**,** Fourier series of function with an arbitrary period, Fourier integrals, Complex Fourier transforms, Fourier sine and cosine transform, Shifting theorem, Fourier transforms of derivatives, Convolution theorem **Module-III** Definition of exponential function, trigonometric, hyperbolic and logarithmic functions. Limit, Continuity, Differentiability of complex valued functions, Analytic function, Cauchy-Riemann Equations in Cartesian and Polar form, Necessary and sufficient conditions for a function to be analytic function, Harmonic functions and simple application to flow problems. **Module-IV** Line integration of complex valued functions, Cauchy theorem, Cauchy Integral formula, Generalized Cauchy Integral formula ,Taylor's and Laurent's series, radius and circle of convergence, Zeroes and Singularities of complex valued functions, Residues, Residue theorem and it's application in evaluation of real Integrals around unit and Semi Circle **Module-V** Solution of Partial differential equations using separation of variables, Application of PDE to solve one dimensional, two-dimensional Heat and Wave equations, Laplace Equations, D'Alembert Solution of Wave equation
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. Kreyszig, E., Advanced Engineering Mathematics, 9e, Wiley Publications,2011. 2. Greenberg, M., Advanced Engineering Mathematics, Prentice Hall, 1998. 3. Jain, R. K., Iyengar, S. R. K., Advanced Engineering Mathematics, Narosa Publications, 2002.

1	**Code of the subject**	BCCS-1201
2	**Title of the subject**	Data Structures
3	**Any prerequisite**	Mathematics-I, Computer Programming: Concepts and Practices
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Saumya Bhadauria
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	This course teaches the basic data structures and algorithms for performing operations on data structures, the use of data structures to provide software solutions that are efficient, and some algorithm paradigms for building efficient algorithms.
8	**Brief Contents (module wise)**	Module I: Introduction to Abstract data types, linear and linked data structures – Arrays, Stacks, Queues, Linked List Module II: Introduction to searching and sorting algorithms –Quick sort, Merge sort, Heap sort, linear time sorting; evaluation of infix/postfix expressions Module III: Trees, binary search trees and basic operations, AVL trees, heaps, hash tables. Module IV: Algorithm analysis: time and space complexity, asymptotic behavior, estimating runtime, comparison of algorithms. Module V: Graphs and basic algorithms on graphs: depth first and breadth first search, Dijkstra's algorithm. Module VI: Hash Tables
9	**Contents for lab (If applicable)**	Mentioned in the Lab Course
10	**List of text books/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**	BCCS-1202
2	**Title of the subject**	Data Base Systems
3	**Any prerequisite**	No
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	This is one of the fundamental subjects of computer science. Therefore, learning objective of this course is to understand about the Database design and perform appropriate modifications on database system logically and practically. Students certainly will use Database systems concept during the logical design of Database systems of future system developments.
8	**Brief Contents (module wise)**	**Module I:** Introduction to Databases **Module II:** Relational Data Model,Relational Algebra: Basic Operators**,** Relational Algebra: Additional Operators**,** Relational Algebra: Updates**,** Entity-Relationship Diagram **Module III:** SQL: Creation and Basic Query Structure**,** SQL: Basic Operations**,** SQL: Aggregate and Grouping**,** SQL: Nested Subqueries and Sets**,** SQL: Updates and Joins**,** SQL: Views and Triggers **Module IV:** Database Normalization: Functional Dependencies**,** Database Normalization: 1NF and 2NF**,** Database Normalization: 3NF**,** Database Normalization: BCNF**,** Database Normalization: Multi-valued Dependencies**,** Database Normalization:PJNF **Module V:** Indexing: Basics and Hashing**,** Indexing: B-tree and B+-tree **Module VI:** Database Transactions: Definition of Transactions**,** Database Transactions: Features of Transactions **Module VII:** Recovery Systems: Types of Recovery Systems**,** Recovery Systems: Log-based Schemes **Module VIII:** Transaction Schedules: Conflicts and Aborts**,** Transaction Schedules: Serializability**,** Transaction Schedules: Recoverability **Module IX:** Concurrency Control Protocols: Two-phase Locking Protocols**,** Concurrency Control Protocols: Timestamp Ordering Protocol**,** Concurrency Control Protocols: Multiple Granularity Locks**,** Concurrency Control Protocols: Deadlock Prevention **Module X:** Query Processing: Selection**,** Query Processing: Sorting**,** Query Processing: Basic Nested Loop Join**,** Query Processing: Block and Indexed Nested Loop Joins**,** Query Processing: Merge and Hash Joins**,** Query Optimization: Equivalent Expressions**,** Query Optimization: Joins**,** Query Optimization: Estimating Sizes
9	**Contents for lab**	NIL
10	**List of text books/references**	1. Abraham Silberschatz, Henry Korth, and S. Sudarshan. 2005. Database Systems Concepts (5ed.). McGraw-Hill, New York, USA. 2. Ramez A. Elmasri, Shankrant B. Navathe. 1999. Fundamentals of Database Systems (3rded.). Carter Shanklin (Ed.). Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA. 3. Paul DuBois. 1999. Mysql. New Riders Publishing, Thousand Oaks, CA, USA. 4. C. J. Date. 2005. Database in Depth: Relational Theory for Practitioners. O'Reilly Media, Inc. 5. Bipin C. Desai. 1990. An Introduction to Database Systems. West Publishing Co., St. Paul, MN, USA.

1	**Code of the subject**	BCAS-1202
2	**Title of the subject**	Discrete Mathematical Structures
3	**Any prerequisite**	NIL
4	**L-T-P**	2-1-0
5	**Name of the proposer**	Anuraj Singh
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ 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
8	**Brief Contents (module wise)**	**Module-I: Fundamentals of Logic**: Proposition, negation, disjunction and conjunction, implication and equivalence, truth tables, predicates, quantifiers, natural deduction, rules of inference, method of proofs, use in program proving, resolution principle **Module-II: Set Theory and Functions:** Inductive definition of sets and proof by induction, Peono postulates, Relations, properties of relations, equivalence relations and partitions; Partial orderings, Posets, Linear and well-ordered sets; Partial Orders -Hasse Diagrams, Equivalence Relations and Partitions. Functions, mappings, injection and surjection, composition of functions, inverse functions, special functions, Peono postulates, pigeonhole principle, recursive function theory **Module-III: Graph Theory:** Basics of Graph Theory, Euler Graph, Hamiltonian path, trees, trees traversals, Spanning trees **Module-IV: Group Theory:** Definition and elementary properties of groups, semigroups, monoids, rings, fields, vector spaces and lattices **Module-V: Elementary Combinatorics**: Fundamental Principles of Counting: The Rules of Sum and Product, recurrence relation, generating functions, Mathematical Induction, Permutations, Combinations , Combinations with Repetition
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	1.Bernanrd Kolman, Robert C Busby, S.Ross, Discrete Mathematical Structures, PHI Learning, 2008 2. Kenneth H. Rosen, Discrete Mathematics and Its Appications, Tata McGraw-Hill Edition, 2015 3. I.N. Herstein, Topics in Algebra, John Wiley Publications, 2006 4. Ralph P. Grimaldi, B.V. Ramana, Discrete and Combinatorial Mathematics, Pearson Education, 2009

1	**Code of the subject**	BCCS-1203
2	**Title of the subject**	Digital Circuits System
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Somesh Kumar
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ To acquaint the students with the basics of digital electronics, number system and Boolean algebra. ➢ Analyze, design and implement combinational and sequential logic circuits. ➢ Classify different semiconductor memories. ➢ Have a thorough understanding of the fundamental concepts and techniques used in digital electronics. ➢ Ability to identify basic requirements for a design application and propose a cost effective solution. ➢ To develop skill to build, and troubleshoot digital circuits and apply it to solve real life problems.
8	**Brief Contents**	**M I: NUMBER SYSTEMS:** Representations, signed, 1's complement, 2's complement, saturation and overflow in fixed point arithmetic. **M II: BOOLEAN ALGEBRA:** Axioms and theorems, DE Morgan's law, universal gate, duality, expression manipulation using axioms and theorems. **M III: COMBINATIONAL LOGIC:** Introduction to switching algebra, canonical forms, two-level simplification, Boolean cube, logic minimization using K-map method, QuineMcCluskey tabular method, minimization for product-of-sum form, minimization for sum-of-product form, multiplexers, Demultiplexers, decoders, encoders, comparators, Arithmetic circuits, adders, half adder, full adder, BCD adder, ripple carry adder, carry-look ahead adder, combinational multiplier. **M IV: SEQUENTIAL LOGIC:** Simple circuits with feedback, basic latches, clocks, R-S latch, master-slave latch, J-K flip flop, T flip-flop, D flip-flop, storage registers, shift register, ripple counter, synchronous counters, Finite State Machine (Moore/Mealy Machines), FSM with single/multiple inputs and single/multiple outputs etc. **M V: INTRODUCTION TO LOGIC FAMILIES:** DTL, RTL, I 2 L, TTL, ECL, CMOS; Parameters of logic families, **M VI: INTRODUCTION TO DIFFERENT TYPES OF MEMORIES:** Programmable Logic Devices and FPGAs.
9	**Contents for lab (If applicable)**	Separate Lab Course is there.
10	**List of text books/references**	1. Digital Design, Morris Mano, Prentice Hall, 2002 2. Digital Fundamentals,10thEd, Floyd T L, Prentice Hall, 2009. 3. Digital Design-Principles and Practices, 4thEd, J F Wakerly, Prentice Hall, 2006. 4. Modern Digital Electronics, 2nd Edition, R.P. Jain. Tata McGraw Hill Company Limited.

1	**Code of the subject**	BCHS 1201
2	**Title of the subject**	Principles & Practices of Management
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Manoj Patwardhan
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	Software engineers need to move beyond the boundaries of their job-specific expertise and enhance their professional profiles by acquiring managerial and interpersonal competences. The Course aims to build the managerial and interpersonal skills by exploring the varied backgrounds, skills, and characteristics required for successful managers. The students will gain the understanding of the functions of management, managerial roles and diverse nature of modern business organizations, rewards & challenges offered by a career in management.
8	**Brief Contents (module wise)**	**Module I** Explain what is meant by the term management Classify the three levels of managers and identify the primary responsibility of each group. Describe the difference between managers and operative employees. Explain the skills and roles manager. Describe the value of studying management. Identify the relevance of popular humanities and social science courses to management practices. **Module II** Define planning. Explain the potential benefits of planning. Distinguish between strategic and tactical plans. Define management by objectives and identify its common elements. Outline the steps in the strategic management process. Explain SWOT analysis. Describe the steps in the decision-making process. Identify the assumptions of the rational decision-making model. Define certainty, risk, and uncertainty as they relate to decision making. Identify the two types of decision problems and the two types of decisions that are used to solve them. Describe the advantages and disadvantages of group decisions. **Module III** Identify and define the six elements of organization structure. Contrast mechanistic and organic organizations. Summarize the effect of strategy, size, technology, and environment on organization structures. Contrast the divisional and functional structures. **Module IV** Define leader and explain the difference between managers& leaders. Describe the skills that visionary leader exhibit. Explain the styles and theories of leadership. Define Motivation at work. Techniques of Motivation. Theories of motivation. Explain what is meant by term learning organization**.** **Module V** Define control. Describe three approaches to control. Explain why control is important. Describe the control process. Distinguish among the three types of control. Describe the qualities of an effective control system. Explain how controls can become dysfunctional. Explaining the concepts of Team work, Team Player, Team Building and the Process of establishing and developing a greater sense of collaboration and trust between members of Software Project Teams.
9	**Contents for lab**	NA
10	**List of text books/references**	1.Management: International Edition, byHitt, Black & Porter 2.Fundamentals of Management: Int. Edition by Robbins & De Cenzo 3.Management: Concepts & Practices by Hannagan

1	**Code of the subject**	BCCS-1204
2	**Title of the subject**	Data Structure Lab
3	**Any prerequisite**	Mathematics-I, Computer Programming: Concepts and Practices
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr. SaumyaBhadauria
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• To develop skills to design and analyse simple linear and non-linear data structures. • To identify and apply the suitable data structure for the given real world problem.
8	**Brief Contents (module wise)**	Module I: Abstract data types, Big-Oh notation, Time and Space complexity; Module II: Programming of linear and linked data structures – Arrays, Stacks, Queues, Linked List; Module III: Programming of sorting algorithms–Quick sort, Merge sort, Heaps Priority queues, Heap sort, linear time sorting; Module IV: Implementing Trees, Dictionaries – Binary search trees, Balanced search trees, AVL trees; Module V: Programming to demonstrate Graph preliminaries, Graph algorithms-BFS, DFS; Problem Solving
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/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**	BCCS-1205
2	**Title of the subject**	Digital Circuits System Lab
3	**Any prerequisite**	NA
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr. Somesh Kumar
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ Theobjective of thislabistounderstandthefundamentalsologicgatesanditsuseinimplementingbasic Booleanfunctions. ➢ To provide hand-on experience in designing and implementing digital/logic circuits. ➢ The laboratory exercises are designed to give students ability to design, build, and implement digital circuits and systems. ➢ Laboratory assignments progress from investigation of the properties of basic logic gates and flip-flops to the design of combinational and sequential circuits
8	**Brief Contents**	**List of Experiments (Hardware):** 1. Study of basic components and ICs used in digital electronics lab. 2. Implementation of basic logic gates using switches, p-n junction diodes and bipolar junction transistor. 3. Study of universal gates and implementation of Boolean functions using NAND and NOR gates. 4. Implementation of 1-bit Full Adder/Subtractor using logic gates. 5. Implementation of 2-bit binary ripple adder using logic gates. 6. Implementation of 3X2 bit binary multiplier using logic gates. 7. Design and implementation of code converters. 8. Realization of Adder and Subtractor circuits using Multiplexer. 9. Study of sequential circuits and implementation of Flip-Flops. 10. Design and implementation of asynchronous decade counter.
9	**Contents for lab (If applicable)**	Mentioned above.
10	**List of text books/references**	1. Digital Design, Morris Mano, Prentice Hall, 2002. 2. Digital Fundamentals,10thEd, Floyd T L, Prentice Hall, 2009. 3. Digital Design-Principles and Practices, 4thEd, J F Wakerly, Prentice Hall, 2006. 4. Modern Digital Electronics, 2nd Edition, R.P. Jain. Tata McGraw Hill Company Limited.

1	**Code of the subject**	BCCS-1206
2	**Title of the subject**	Data Base Systems Lab
3	**Any prerequisite**	No
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	This is one of the fundamental subjects of computer science. Therefore, learning objective of this course is to understand about the Database design and perform appropriate modifications on database system logically and practically. Students certainly will use Database systems concept during the logical design of Database systems of future system developments.
8	**Brief Contents (module wise)**	**Module I:** • Study of problem analysis techniques **Module II:** • Drawing of Entity-Relationship Diagram **Module III: Hands on SQL for the following:** • SQL: Creation and Basic Query Structure • SQL: Basic Operations • SQL: Aggregate and Grouping • SQL: Nested Subqueries and Sets • SQL: Updates and Joins • SQL: Views and Triggers **Module IV: Practical study on Normalization** • Database Normalization: Functional Dependencies • Database Normalization: 1NF and 2NF • Database Normalization: 3NF • Database Normalization: BCNF • Database Normalization: Multi-valued Dependencies • Database Normalization:PJNF **Module V:** • Coming up with the applying knowledge to implement a realistic project.
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	1Abraham Silberschatz, Henry Korth, and S. Sudarshan. 2005. Database Systems Concepts (5 ed.). McGraw-Hill, Inc., New York, NY, USA. 2Ramez A. Elmasri, Shankrant B. Navathe. 1999. Fundamentals of Database Systems (3rd ed.). Carter Shanklin (Ed.). Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA. 3Paul DuBois. 1999. Mysql. New Riders Publishing, Thousand Oaks, CA, USA. 4C. J. Date. 2005. Database in Depth: Relational Theory for Practitioners. O'Reilly Media, Inc. 5Bipin C. Desai. 1990. An Introduction to Database Systems. West Publishing Co., St. Paul, MN, USA.

Semester-III

1	**Code of the subject**	BCAS-2101
2	**Title of the subject**	Probability and Statistics
3	**Any prerequisite**	NIL
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr Ajay Kumar
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To introduce students about basics of probability theory and statistics.
8	**Brief Contents (module wise)**	Introduction, Measures of Central Tendency and Dispersion in Frequency Distributions, Arithmetic Mean, Weighted Mean, Geometric Mean, Median, Mode, Dispersion, Ranges, Coefficient of Variation. Probability, Basic terminology, Types of Probability, Probability rules, Bayes Theorem, Probability distribution, Binomial, Poisson, Negative-Binomial, Geometric, Hypergeometric, Uniform, Exponential, Normal distribution, log-normal, beta and gamma distributions. Sampling and Sampling Distribution, Random sampling, Design of Experiments, Sampling distribution, Relationship between sample size and standard error, estimation theory. Testing Hypotheses: One Sample Test, Basics to hypotheses – testing procedure, Testing hypotheses, Hypotheses testing of means, measuring the power of hypotheses test. Testing Hypotheses: Two Sample Test, Testing for differences between means and proportions, Testing differences between means with dependent samples, Probability values. Chi – Square distribution, Chi – Square as a test of independence, Testing the appropriateness of a distribution, Analysis of variance, Inference about a population variance. Simple Regression and Correlation: Estimation using the regression line, Correlation analysis, making inferences about population parameters. Multiple Regression: Multiple regression and correlation analysis, Finding multiple regression equation, Inferences about population parameters.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. Johnson, R. A., Miller & Freund's Probability and statistics for engineers, Pearson Education, 2000. 2. Hogg R. V., Craig A., Probability and Statistical Inference, 6th edition, Pearson Education. 3. Ross S. M., First Course in Probability, Pearson Education.

1	**Code of the subject**	BCS2101
2	**Title of the subject**	Analysis and Design of Algorithms
3	**Any prerequisite**	Data Structures, C programming, Mathematics
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	This is one of the fundamental subjects of computer science. Therefore, learning objective of this course is to understand about the algorithms and to develop the confidence for design and analyze the algorithms in order to make decisions about the good and bad algorithms. This course covers topics on motivation,Asymptoticcomplexity,binary search,Sorting,Graphs,Priority queues, heaps,Search Trees,Dynamic Programming & Intractability.Students certainly will be able to develop best algorithms which cane be utilized forfuture system developments.
8	**Brief Contents (module wise)**	**Module 1:** Introduction,Examples and motivation, Asymptotic complexity: informal concepts, Asymptotic complexity: formal, notation, Asymptotic complexity: example **Module 2:** Searching in list: binary search, Sorting: insertion sort, Sorting: selection sort, Sorting: merge sort, Sorting: quicksort, Sorting: stability and other issues **Module 3:** Graphs: Motivation, Graph exploration:BFS,Graph exploration: DFS, DFS numbering and applications, Directed acyclic graphs, Directed acyclic graphs **Module 4:** Shortest paths: unweightedandweighted, Single source shortest paths: Dijkstra, Single source shortest paths: Dijkstra, Minimum cost spanning trees:Prim's, algorithm, Minimum cost spanning trees: Kruskal's Algorithm, Union-Find data structure **Module 5:** Divide and conquer: counting, inversions, Divide and conquer: nearest pair of points, Priority queues, heaps, Priority queues, heaps, Dijstra/Prims revisited using heaps, Search Trees: Introduction **Module 6:** Search Trees: Traversals, insertions, deletion, Search Trees:Balancing, Greedy : Interval scheduling, Greedy :Proof strategies,Greedy : Human coding, Dynamic Programming: weighted interval scheduling **Module 7:** Dynamic Programming: memoization, Dynamic Programming: edit distance, Dynamic Programming: longest ascending subsequence, Dynamic Programming: matrix multiplication, Dynamic Programming: shortest paths: Bellman Ford, Dynamic Programming: shortestpaths: Floyd Warshall **Module 8:** Intractability: NP completeness, Intractability:reductions, Intractability: examples, Intractability: more examples, Misc topics
9	**Contents for lab**	NIL
10	**List of text books/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**	BCCS-2102
2	**Title of the subject**	Computer Organization and Architecture
3	**Any prerequisite**	Fundamentals of Computing; Digital Circuits System
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Prasenjit Chanak
6	**Will this course require visiting faculty**	NA
7	**Learning Objectives of the subject**	This course will teach the fundamentals of Computer Organization and Architecture and elaborate on the Application Binary Interfaces described.
8	**Brief Contents (module wise)**	**Basic functional blocks of a computer:** CPU, memory, input-output subsystems, control unit. Instruction set architecture of a CPU - registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set. Case study - instruction sets of some common CPUs. **Data representation:** signed number representation, fixed and floating point representations, character representation. Computer arithmetic - integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication - shift-and-add, Booth multiplier, carry save multiplier, etc. Division - non-restoring and restoring techniques, floating point arithmetic. **CPU control unit design:** hardwired and micro-programmed design approaches, Case study - design of a simple hypothetical CPU. **Memory system design:** semiconductor memory technologies, memory organization. **Peripheral devices and their characteristics:** Input-output subsystems, I/O transfers - program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes - role of interrupts in process state transitions. **Performance enhancement techniques** **Pipelining:** Basic concepts of pipelining, throughput and speedup, pipeline hazards. Memory organization: Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs block size, mapping functions, replacement algorithms, write policy.
9	**Contents for lab (If applicable)**	a. Digital Design using HDLs. Simple circuit designs: For e.g. Counter, Multiplexer, Arithmetic circuits etc. Design of a Simple Processor: Includes register file, ALU, data paths. b. FPGA Programming Programming on Xilinx Spartan 3E (or equivalent) FPGA. Handling of Inputs: through slide switches, through push buttons. Handling of Outputs: 7-segment display, LED display, LCD display. The designs developed in Part-I can be used to program the FPGA. c. Assembly Language Programming Programming in assembly language. The assignments should cover the following concepts: Registers; different type of instructions (load, store, arithmetic, logic, branch); operand addressing modes; memory addressing modes; conditions (codes/flags and conditional branches) stack manipulation; procedure calls; procedure call conventions (load/store of; arguments on stack, activation records);
10	**List of text books/references**	1. Computer Organization and Design: The Hardware/Software Interface, David A Patterson, John L. Hennessy, 4th Edition, Morgan Kaufmann, 2009 2. Computer Architecture and Organization by William Stallings, PHI Pvt. Ltd., Eastern Economy Edition, Sixth Edition, 2003 3. Structured Computer Organization by Andrew S Tanenbaum, PHI/Pearson, 4th Edition 4. Computer Organization by V Carl Hamacher, ZvonksVranesic, SafeaZaky, McGraw Hill, Vth Edition 5. Computer System Architecture by M Morris Mano, Prentice Hall of India, 2001 6. Computer Architecture and Organization by John P Hayes, 3rd Ed. McGraw Hill, 2002.

1	**Code of the subject**	BCCS-2103
2	**Title of the subject**	Operating Systems
3	**Any prerequisite**	Computer Organization; Data Structures and Computer Programming
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Shashikala Tapaswi
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The course aims to explore the importance of the operating system and its function. The different 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. Also, the course throws light on the existing operating systems and the concepts of Operating Systems are applied in these systems. Introduction and history of Operating systems, structure and operations; processes and files; Processor management: inter process communication, process scheduling and algorithms, critical sections, threads, multithreading; Memory management: contiguous memory allocation, virtual memory, paging, page table structure, demand paging, page replacement policies, thrashing, segmentation, case study; Deadlock: Shared resources, resource allocation and scheduling, resource graph models, deadlock detection, deadlock avoidance, deadlock prevention algorithms, mutual exclusion, semaphores, wait and signal procedures; Device management: devices and their characteristics, device drivers, device handling, disk scheduling algorithms and policies, File management: file concept, types and structures, directory structure, cases studies, access methods and matrices, file security, user authentication; UNIX operating system as a case study. By the end of this course the student will be able to understand: 1. The importance of the operating systems. 2. The application interaction with the operating system as it works as intermediary program between the machine and the application. 3. The way operating systems transport the application requests to the hardware. 4. The way operating systems managing resources such as processors, memory and I/O. 5. The advantages and drawbacks of the different techniques used by some operating systems.
8	**Brief Contents (module wise)**	Topics to be covered: Introduction and history of Operating systems:- structure and operations; processes and files; Computer system organization (Computer Hardware) consists of :Device, Device controller, Interrupt, Device and CPU interaction, Bootstrap program I/O structure:-Polling, interrupt, and DMA, resolve interrupt through interrupt vector, Computer System Architecture, Single Processor System, Multiple Processors System, advantages of using multiple processor system, Operating System Structure and Operations, Dual Modes operation, Timer, Process management, Storage management Processes**:-**Processor management: inter process communication, mutual exclusion, semaphores, wait and signal procedures, process scheduling and algorithms, critical sections, threads, multithreading; Process concept, PCB, Process state, Process scheduling (long, medium and short term schedulers), Process operations, Interprocess communication , Techniques of Intercrosses communication, Message passing, Shared memory, Client server CPU scheduling :- Preemptive and non-preemptive scheduling, scheduling criteria, algorithms: FCFS, SJF + Prediction of next burst of SJF, Priority Scheduling, Round Robin, Multilevel Queues, Multilevel feedback. Process Synchronization : Introduction and background, Critical section (C.S.) problem, Condition for the solutions of C.S., Algorithms: Peterson, Hardware solutions, Semaphores, Monitors Main Memory Management:-Memory management: contiguous memory allocation,

		Basic Hardware for managing Memory, Address binding, Contiguous allocation (based on fixed and variable partitions), Relocation and protection problems, Fragmentation, Non-contiguous allocation. Virtual memory, paging, paging + hardware supportpage table structure, demandpaging, page replacement policies, thrashing, Segmentation, Paging with Segmentation. Deadlock:- Shared resources, resource allocation and scheduling, resource graph models, deadlock detection, deadlock avoidance, deadlock prevention algorithms Device management:- devices and their characteristics, device drivers, device handling, disk scheduling algorithms and policies File management:- file concept, types and structures, directory structure, cases studies, access methods and matrices, file security, user authentication; File Systems:-File system structure, Implementation, Partition and mounting, Allocation methods: Contiguous, Linked, Indexed Free space Management: Bit vector, Linked list Case Studies:- UNIX and Linux operating systems as case studies; Mobile OS
9	**Contents for lab (If applicable)**	-
10	**List of text books/references**	***References:*** 1. A. Silberschatz& P.B. Galvin, 'Operating System concepts and principles', Wiley India, 8th ed., 2009. 2. A. Tanenbaum, 'Modern Operating Systems', Prentice Hall India, 2003. 3. W. Stallings, 'Operating Systems: Internals and design Principles', Pearson Ed., LPE, 6th Ed., 2009. 4. M.J. Bach, 'Design of Unix Operating system', Prentice Hall, 1986. ***Additional Reading:*** 1. D.M. Dhamdere, 'Operating Systems: a concept based approach', Tata McGraw-Hill Pubs., 2nd ed., 2006. 2. G. Glass, 'Unix for programmers and users-a complete guide', Pearson Ed., 3rd ed., 2005.

1	**Code of the subject**	BCCS-2104
2	**Title of the subject**	Object Oriented Programming Language
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Santosh Singh Rathore
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• To develop programming skill and to solve engineering related problems using Object OrientedProgramming Concepts.
8	**Brief Contents (module wise)**	**Module I:** Object oriented thinking: Need for OOP Paradigm, Procedural programming vs object oriented programming, object oriented concepts. **Module II:** Class and object concepts: Difference between C structure and class, specifying a class, Defining members inside and outside class, etc. **Module III:** Constructor and destructor concepts, Operator overloading and Type Conversion, Inheritance and polymorphism concepts **Module IV:** 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. **Module V:** Templates: Class template, class template with parameter, function template, function template with parameter and Exception handling
9	**Contents for lab (If applicable)**	None
10	**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.

1	**Code of the subject**	BCHS-2101
2	**Title of the subject**	Environmental Sciences
3	**Any prerequisite**	-
4	**L-T-P**	2-0-0
5	**Name of the proposer**	Dr. Arun Kumar
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	➢ To develop an understanding of the environment, resources and climate change issues. ➢ To enable the students to assess the environmental impact. ➢ To understand the linkage between biology, physics, chemistry, earth and atmospheric sciences.
8	**Brief Contents (module wise)**	➢ Introduction to environmental science ➢ Environmental interactions, cycles and systems ➢ Ecology and environmentalism ➢ Formation and structure of the earth ➢ Weathering ➢ Energy ➢ Composition and structure of atmosphere ➢ Climate change ➢ Involvement and role of communities ➢ Physical resources ➢ Irrigation ➢ Soil formation ➢ Mining and processing of fuels and minerals ➢ Biosphere, biomes and biogeography ➢ Biological resources ➢ Environmental management ➢ Case studies on Air Pollutants, Polluted soils, Treatment of waste etc.
9	**Contents for lab (If applicable)**	-
10	**List of text books/references**	1. M. Allaby, Basics of Environmental Sciences, Routledge Publication, 2nd edition, 2000 2. Tanu Jindal, Emerging Issues in Ecology and Environmental Science: Case Studies from India, Springer International Publishing, 1st edition, 2019

1	**Code of the subject**	BCCS-2105
2	**Title of the subject**	Analysis and Design of Algorithms lab
3	**Any prerequisite**	Data Structures, C programming, Mathematics
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	This is one of the fundamental subjects of computer science. Therefore, learning objective of this course is to understand about the algorithms and to develop the confidence for design and analyze the algorithms in order to make decisions about the good and bad algorithms. This course covers topics on motivation, Asymptotic complexity, binary search, Sorting, Graphs, Priority queues, heaps, Search Trees, Dynamic Programming & Intractability. Students certainly will be able to develop best algorithms which cane be utilized forfuture system developments.
8	**Brief Contents (module wise)**	**Module I:** • Programming of linear and linked data structures – Arrays, Stacks, Queues, Linked List • Implementations of various searching/sorting algorithms- Quick sort, Merge sort, Heaps Priority queues, Heap sort, linear time sorting; Linear Serach, Binary search trees etc. **Module II:** • Implementations of divide and conquer approaches on several algorithms **Module III:** • Implementations of several Dynamic Programming (DP) based algorithms **Module IV:** • Implementation of various trees algorithms: Traversals, insertions, deletion, Search Trees **Module V:** • Implementation of various graph algorithms: Traversals, insertions, deletion, Search Trees, Minimum spinning tress etc. **Module VI:** • Implementation of Various Greedy algorithms
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/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**	BCCS-2106
2	**Title of the subject**	Operating System Lab
3	**Any prerequisite**	Computer Organization; Data Structures and Computer Programming, Unix commands
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Shashikala Tapaswi
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	**The lab sessions aim to make student to develop :** 1. Ability to develop application programs using system calls in Linux/Unix. 2. Ability to implement interprocess communication between two processes. 3. Ability to design and solve synchronization problems. 4. Ability to simulate and implement operating system concepts such as scheduling, deadlock management, file management, and memory management.
8	**Brief Contents (module wise)**	**Use Linux operating system and GNU C compiler.** 1. To write programs in Linux environment using system calls. 2. To understand basics of Linux/Unix commands; Shell Programming. 3. To write C programs to simulate the following File organization techniques: a) Single level directory b) Two level c) Hierarchical. 4. To implement the scheduling algorithms such as FCFS, Round Robin, SJF, Priority. 5. To implement file allocation methods: a)Contiguous b)Linked c)Indexed 6. To implement an algorithm for Dead Lock Detection , Bankers algorithm for Dead Lock Avoidance 7. To implement paging /segmentation/page replacement algorithms 8. To implement concepts of Threading 9. To implement and develop solutions for synchronization problems using semaphores etc 10. To understand and implement IPC mechanism using named and unnamed pipes.
9	**Contents for lab (If applicable)**	Mentioned at point 9
10	**List of text books/references**	**REFERENCE BOOKS:** 1. An Introduction to Operating Systems, P.C.P Bhatt, 2nd edition, PHI. 2. Unix System Programming Using C++, Terrence Chan, PHI/Pearson. 3. Modern Operating Systems, Andrew S Tanenbaum, 3rd Edition, PHI

1	**Code of the subject**	BCCS-2107
2	**Title of the subject**	Object Oriented Programming Language Lab
3	**Any prerequisite**	None
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr. Santosh Singh Rathore
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• To gain understanding about the object oriented principles in construction of robust and maintainable programs. • To have a competence to design, write, compile, test and execute programs using high level language.
8	**Brief Contents (module wise)**	**Module I:** Demonstration of the use of basic C++ syntaxes and functions. **Module II:** Demonstration **of** the use of class and objects concepts. **Module III:** Demonstrationof the concept of:Default constructor, Parameterized constructor, Copy constructor, Constructor overloading, destructor. **Module IV:** Demonstration ofthe concepts of inheritance: multiple inheritance, multilevel inheritance, hybrid inheritance, containership. **Module V:** Demonstration of the concepts of operator overloading: overload unary operator, overload binary operator **Module VI:** Demonstration of the concept of polymorphism (static and run-time) and virtual functions. **Module VII:** Demonstration of the use of template in object-oriented programming. **Module VIII:** Demonstration of the use of exception handling concepts in C++.
9	**Contents for lab (If applicable)**	None
10	**List of text books/references**	1. HM Deitel and PJ Deitel "C++ How to Program", Seventh Edition, 2010, Prentice Hall, Education. 2. Robert Lafore, "Object Oriented Programming in C++", 2002, Pearson education. 3. Bruce Eckel, "Thinking in C++", vol 1, edition 2, President, MindView Inc., 1999.

Semester-IV

1	**Code of the subject**	BCCS-2201
2	**Title of the subject**	Theory of Computation
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. W. Wilfred Godfrey
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To introduce students to the mathematical foundations of computation including automata theory; the theory of formal languages and grammars; the notions of algorithm, decidability, complexity, and computability. ➢ To enhance/develop students' ability to understand and conduct mathematical proofs for computation and algorithms.
8	**Brief Contents (module wise)**	**Module I - Finite Automata:** Introduction- Basic Mathematical Notation and techniques- Finite State systems – Basic Definitions – Finite Automaton – DFA & NDFA – Finite Automaton with €- moves – Regular Languages- Regular Expression – Equivalence of NFA and DFA – Equivalence of NDFA‟s with and without €-moves – Equivalence of finite Automaton and regular expressions –Minimization of DFA- – Pumping Lemma for Regular sets – Problems based on Pumping Lemma. **Module II – Grammars:** Grammar Introduction– Types of Grammar – Context Free Grammars and Languages– Derivations and Languages – Ambiguity- Relationship between derivation and derivation trees – Simplification of CFG – Elimination of Useless symbols – Unit productions – Null productions – Greiback Normal form – Chomsky normal form – Problems related to CNF and GNF. **Module III -Pushdown Automata:** Pushdown Automata- Definitions – Moves – Instantaneous descriptions – Deterministic pushdown automata – Equivalence of Pushdown automata and CFL – pumping lemma for CFL – problems based on pumping Lemma. **Module IV - Turing Machines:** Definitions of Turing machines – Models – Computable languages and functions –Techniques for Turing machine construction – Multi head and Multi tape Turing Machines – The Halting problem – Partial Solvability – Problems about Turing machine- Chomskian hierarchy of languages. **Module V - Unsolvable Problems and Computable functions:** Unsolvable Problems and Computable Functions – Primitive recursive functions – Recursive and recursively enumerable languages – Universal Turing machine. Measuring and classifying complexity: Tractable and Intractable problems- Tractable and possibly intractable problems – P and NP completeness – Polynomial time reductions.
9	**Contents for lab (If applicable)**	Nil
10	**List of text books/references**	**TEXTBOOKS** 1. Hopcroft J.E., Motwani R. and Ullman J.D, “Introduction to Automata Theory, Languages and Computations”, Second Edition, Pearson Education, 2008. 2. John C Martin, “Introduction to Languages and the Theory of Computation”, Third Edition, Tata McGraw Hill Publishing Company, New Delhi, 2007. **REFERENCES** 1.Mishra K L P and Chandrasekaran N, “Theory of Computer Science – Automata, Languages and Computation”, Third Edition, Prentice Hall of India, 2004. 2.Harry R Lewis and Christos H Papadimitriou, “Elements of the Theory of Computation”, Second Edition, Prentice Hall of India, Pearson Education, New Delhi, 2003. 3.Peter Linz, “An Introduction to Formal Language and Automata”, Third Edition, Narosa Publishers, New Delhi, 2002. 4.KamalaKrithivasan and Rama. R, “Introduction to Formal Languages, Automata Theory and Computation”, Pearson Education 2009

1	**Code of the subject**	BCCS-2202
2	**Title of the subject**	Artificial Intelligence
3	**Any prerequisite**	Algorithm and Data Structures
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Ritu Tiwari
6	**Will this course require visiting faculty**	
7	**Learning Objectives of the subject (in about 50 words)**	There are many cognitive tasks that people can do easily and almost unconsciously but that have proven extremely difficult to program on a computer.Artificial intelligence involves the development of computer systems th at can carry out these tasks.We will focus on three central areas in AI: Problem Solving & Game Playing, representation and reasoning, natural language processing,
8	**Brief Contents (module wise)**	**Introduction to AI and intelligent agents**. **Problem Solving:** Solving Problems by Searching, heuristic search techniques, constraint satisfaction problems, stochastic search methods. **State Space Search:** Depth First Search, Breadth First Search **Heuristic Search:** Best First Search, Hill Climbing **Finding Optimal Paths:** Branch and Bound, A*, IDA* **Game Playing**: minimax, alpha-beta pruning. **Knowledge and Reasoning**: Building a Knowledge Base: Propositional logic, first order logic, situation calculus. Theorem Proving in First Order Logic.Planning, partial order planning. Uncertain Knowledge and Reasoning, Probabilities, Bayesian Networks. **Learning**: Overview of different forms of learning, Learning Decision Trees, Artificial Neural Networks and Fuzzy Approaches. **Introduction to Natural Language Processing.**
9	**Contents for lab (If applicable)**	1. Write a program to implement Tic-Tac-Toe game problem 2. Write a program to implement BFS (for 8 puzzle problem or Water Jug problem or any AI search problem) 3. Write a program to implement DFS (for 8puzzle problem or Water Jug problem or any AI search problem) 4. Write a program to implement Single Player Game (Using Heuristic Function). 5. Write a program to Implement A* Algorithm. 6. Write a program to solve N-Queens problem. 7. Write a program for tower of Hanoi problem. 8. Write a program to solve travelling salesman problem. 9. Write a program that will take as input two Web page URLs and find a path of links from one to the other. What is an appropriate search strategy? 10. Implement a performance-measuring environment simulator for the vacuum-cleaner World. Your implementation should be modular so that the sensors, actuators, and environment characteristics (size, shape, dirt placement, etc.) can be changed easily. 11. Implement a simple reflex agent for the vacuum environment in above experiment. Run the environment with this agent for all possible initial dirt configurations and agent locations.Record the performance score for each configuration and the overall average score.
10	**List of text books/references**	**Text Books:** 1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003; 2. Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill **Reference Books:** 1. Patrick Henary Winston, Artificial Intelligence, Pearson publication; 2. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India); 3. Eugene Charnaik and Drew McDermott, Introduction to Artificial Intelligence, Pearson publication; 4. Nils John Nilsson, The Quest for Artificial Intelligence: A History of Ideas and Achievements, Morgan Kaufman Publication; 5. Dennis Rothman, Artificial Intelligence by Example,

1	**Code of the subject**	BCCS-2203
2	**Title of the subject**	Computer Networks
3	**Any prerequisite**	No
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. K. K. Pattanaik
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The course will help understand the purpose and overview of the Internetworking technology, issues, and approaches using top-down philosophy.
8	**Brief Contents (module wise)**	**Chapter I** Computer Networks and the Internet A Nuts-and-Bolts Description of Internet, A Services Description, The Network Edge, Client and Server Programs, The Network Core, ISPs and Internet Backbones, Performance in Packet-Switched Networks, Protocol Layers and Their Service Models, The Development of Packet Switching, Proprietary Networks and Internetworking, The Internet Explosion, Recent Developments. **Chapter II** Application Layer Network Application Architectures, Processes Communication, Transport Services, Transport Services, Application-Layer Protocols, The Web and HTTP, User-Server Interaction: Cookies, Web Caching, Peer-to-Peer Applications, P2P File Distribution, Searching for Information in a P2P Community, Case Study: P2P Internet Telephony with Skype, Socket Programming with TCP and UDP **Chapter III** Transport Layer Relationship Between Transport and Network Layers Overview of the Transport Layer in the Internet, Principles of Reliable Data Transfer Building a Reliable Data Transfer Protocol, Pipelined Reliable Data Transfer Protocols, Round-Trip Time Estimation and Timeout, Principles of Congestion Control, The Causes and the Costs of Congestion, Approaches to Congestion Control, TCP Congestion Control, Fairness. **Chapter IV** The Network Layer Network Service Models, Datagram Networks, Router architecture: Input Ports, Switching, Output Ports, Queuing. The Internet Protocol (IP),IP Security VPNs, Routing, Broadcast and Multicast Routing. **Chapter V** The Link Layer and Local Area Networks Link Layer Services, Multiple Access protocols, Link-Layer Addressing, Ethernet, Link-Layer, PPP: The Point-to-Point Protocol, Link Virtualization. **Chapter VI** Wireless and Mobile Networks Wireless Links and Network Characteristics, WiFi: 802.11 Wireless LANs, Beyond 802.11: Bluetooth and WiMax, Cellular Internet Access, Mobile IP.
9	**Contents for lab**	No
10	**List of text books/references**	Computer Networking: A top-down approach featuring the Internet / James F. Kurose , Keith W. Ross., 7th edition, Pearson.

1	**Code of the subject**	BCCS-2204
2	**Title of the subject**	Software Engineering
3	**Any prerequisite**	NIL
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr Ajay Kumar
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To impart software engineering concepts.
8	**Brief Contents (module wise)**	Introduction: Software engineering approach to solve problems of software industry. Software processes: software development process, project management process. Software requirement Analysis and specification: Software requirements, Problem analysis, requirement specification and validation. Software planning: Cost estimation, COCOMO model, staffing and personnel planning, software configuration and management plan, quality assurance plan, monitoring plans. Software design: design concepts, abstraction, modularity, structure, concurrency, information hiding, coupling and cohesion. Detailed design considerations, verification. Complexity, metrics. Implementation issues: standards and guidelines. Verification and validation techniques: Quality assurance, static analysis, Symbolic execution, unit testing , metrics Testing Fundamentals, Functional testing , Testing Process. Software quality and reliability. The need for system software reliability, software-related problems, software reliability engineering, future problems in the twenty-first century System Reliability Concepts: Reliability measures, common distribution functions (Binominal, Poisson, Exponential, memorylessness, Normal, log-normal, Weibull, Gama, Beta, Parato, and Rayleigh), Poisson process and NHPP.
9	**Contents for lab (If applicable)**	Yes
10	**List of text books/references**	1. Pham, Hoang. System software reliability. Springer Science & Business Media, 2007. 2. JalotePankaj, 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**	BCCS-2205
2	**Title of the subject**	Artificial Intelligence Lab
3	**Any prerequisite**	Algorithm and Data Structures
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr. Ritu Tiwari
6	**Will this course require visiting faculty**	NA
7	**Learning Objectives of the subject (in about 50 words)**	There are many cognitive tasks that people can do easily and almost unconsciously but that have proven extremely difficult to program on a computer.Artificial intelligence involves the development of computer syste ms that can carry out these tasks.We will focus on three central areas in AI: Problem Solving & Game Playing, representation and reasoning, natural language processing,
8	**Contents for lab**	1. Write a program to implement Tic-Tac-Toe game problem 2. Write a program to implement BFS (for 8 puzzle problem or Water Jug problem or any AI search problem) 3. Write a program to implement DFS (for 8puzzle problem or Water Jug problem or any AI search problem) 4. Write a program to implement Single 5. Player Game (Using Heuristic Function). 6. Write a program to Implement A* Algorithm. 7. Write a program to solve N-Queens problem. 8. Write a program for tower of Hanoi problem. 9. Write a program to solve travelling salesman problem. 10. Write a program that will take as input two Web page URLs and find a path of links from one to the other. What is an appropriate search strategy? 11. Implement a performance-measuring environment simulator for the vacuum-cleaner World. Your implementation should be modular so that the sensors, actuators, and environment characteristics (size, shape, dirt placement, etc.) can be changed easily. 12. Implement a simple reflex agent for the vacuum environment in above experiment. Run the environment with this agent for all possible initial dirt configurations and agent locations.Record the performance score for each configuration and the overall average score.
9	**List of text books/references**	**Text Books:** 1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003 2. Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill **Reference Books:** 3. Patrick Henary Winston, Artificial Intelligence, Pearson publication 4. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India) 5.Eugene Charnaik and Drew McDermott, Introduction to Artificial Intelligence, Pearson publication 2. Nils John Nilsson, The Quest for Artificial Intelligence: A History of Ideas and Achievements, Morgan Kaufman Publication 3. Dennis Rothman, Artificial Intelligence by Example,

1	**Code of the subject**	BCCS-2206
2	**Title of the subject**	Computer Network Lab
3	**Any prerequisite**	Fundamentals of Computer Networks
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr. K. K. Pattanaik
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The course will help gaining hands on experience about addressing, communicating among machines, application server configuration.
8	**Brief Contents (module wise)**	Experiment 1: Demonstration of basic concepts of network topology. Creating a small network topology by connecting end devices with switches and routers, configuring end devices and routers, Perform communication between end-devices Experiment 2: Realizing the concepts of IPv4 addressing, subnetting, and subnet masking Experiment 3: Demonstrating the functionality of a Hub and Switch. In addition, understanding the concept of DHCP server and its configuration. Experiment 4: Variable Length Subnet Masking (VLSM) + Static Routing Experiment 5: Demonstrating client-server model with different independent application servers. Experiment 6: Demonstrating client-server model with one multi-application (Email, FTP, HTTP, DNS, and DHCP) server. Experiment 7: Client-server model through Socket Programming in C.
9	**Contents for lab (If applicable)**	--
10	**List of text books/references**	--

1	**Code of the subject**	BCCS-2207
2	**Title of the subject**	Software Engineering Lab
3	**Any prerequisite**	NIL
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr Ajay Kumar
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To impart software engineering concepts.
8	**Brief Contents (module wise)**	a) Student Result Management System b) Library management system c) Inventory control system d) Accounting system e) Fast food billing system f) Bank loan system g) Blood bank system h) Railway reservation system i) Automatic teller machine j) Video library management system k) Hotel management system l) Hostel management system m) E-ticking n) Share online trading o) Hostel management system p) Resource management system q) Court case management system
9	**Contents for lab (If applicable)**	Written above
10	**List of text books/references**	1. Pham, Hoang. System software reliability. Springer Science & Business Media, 2007. 2. JalotePankaj, An Integrated Approach to Software Engineering, Narosa Publishing House 3. Pressman, Roger S., Software Engineering : A practitioner's Approach, McGraw-Hill, Inc.

Summer Project

1	**Code of the subject**	BCCS-2999
2	**Title of the subject**	Minor Project (Summer Project)
3	**Any prerequisite**	
4	**L-T-P**	0-0-6 (3 credit course)
5	**Name of the proposer**	Dr. W. Wilfred Godfrey
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	To develop a component level understanding and interfacing experience in the development of a hardware + software based system which has a real life application
8	**Brief Contents (module wise)**	The students are encouraged to take up Real Life Applications (eg. Campus/classroom based/societal based applications) / incorporating software and Hardware basing Research problems from fields such as cryotography, networking, image processing, IoT, WiFi, Sensors/Electronics etc. Topics are not limited but projects should be hardware oriented and related to Computer Science and Engineering.
9	**Contents for lab (If applicable)**	Nil
10	**List of text books/references**	

Semester-V

1	**Code of the subject**	BCCS-3101
2	**Title of the subject**	Computer Graphics
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Mahua Bhattacharya
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	Computer Graphics is the illustration field of Computer Science. Its use today spans virtually all scientific fields and is utilized for design, presentation, education and training. Computer Graphics and its derivative, *visualization*, have become the primary tools by which the flood of information from Computational Science is analyzed.
8	**Brief Contents (module wise)**	1. Introduction of computer graphics, Graphic Displays- Random scan displays, Raster scan displays, Points and lines, Line drawing algorithms, Circle generating algorithms, Mid-point circle generating algorithm, and parallel version of these algorithms. 2. Three Dimensional: 3-D Geometric Primitives, 3-D Object representation, 3-D Transformation, 3-D viewing, projections, 3-D Clipping. 3. Transformations: Basic transformation, Matrix representations and homogenous coordinates, Composite transformations, 4. Windowing and Clipping: Viewing pipeline, Viewing transformations, 2-D Clipping algorithms- Cohen Sutherland line clipping algorithm, Liang Barsky algorithm, Line clipping against non-rectangular clip windows; Weiler and Atherton polygon clipping, Curve clipping, Text clipping 5. Hidden Lines and Surfaces: Back Face Detection algorithm, Depth buffer method
9	**Contents for lab (If applicable)**	Graphic Displays, viewing, projections, 3-D Clipping. : Basic transformation, Matrix representations and homogenous coordinates, Composite transformations , 2-D Clipping algorithms- Cohen Sutherland line clipping algorithm
10	**List of text books/references**	1.Computer Graphics, C Version Donald D Hearn, M. Pauline Baker 2. Computer Graphics: Principles and Practiceby James D. Foley, Andries van Dam , Steven K. Feiner

1	**Code of the subject**	BCCS-3102
2	**Title of the subject**	Data Mining and Data Warehouse
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr Santosh Singh Rathore
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• Design a data mart or data warehouse for any organization • Extract knowledge using data mining techniques • Explore recent trends in data mining such as web mining, spatial-temporal mining
8	**Brief Contents (module wise)**	**Module I:** Data Mining Concepts, Input, Instances, Attributes and Output, Knowledge Representation & Review of Graph Theory, Statistics, Supervised Learning Framework, concepts & hypothesis, Training & Learning, Boolean functions and formulae, Monomials, a learning algorithm for monomials **Module II:** Data Cleaning, Data Integration & Transformation, Data Reduction **Module III:** Associations, Maximal Frequent & Closed Frequent item sets, Covering Algorithms & Association Rules, Linear Models & Instance-Based Learning, Mining Association Rules from Transactional databases, Mining Association Rules from Relational databases & Warehouses, Correlation analysis & Constraint-based Association Mining. **Module IV:** Issues regarding Classification & Prediction, Classification by Decision Tree induction, Bayesian classification, Classification by Back Propagation, k-Nearest Neighbor Classifiers, Genetic algorithms, Rough Set & Fuzzy Set approaches. Types of data in Clustering Analysis, Categorization of Major Clustering methods, Hierarchical methods, Density-based methods, Grid-based methods, Model-based Clustering methods **Module V:** Multidimensional analysis & Descriptive mining of Complex data objects, Mining Spatial Databases, Mining Multimedia Databases, Mining Time-series & Sequence data, Mining Text databases, Mining WWW **Module VI:** Data warehousing Components, Building Data warehouse, Mapping Data Warehouse to Multiprocessor Architecture, DBMS Schemas for Decision Support, Data Extraction, Transformation Tools, Metadata
9	**Contents for lab**	None
10	**List of text books/references**	1.Jiawei Han and MichelineKamber, "Data Mining: Concepts and Techniques", Morgan Kaufmann Publishers, 2000 (ISBN: 1-55860-489-8). 2.Ian H. Witten and Eibe Frank, "Data Mining: Practical Machine Learning Tools and Techniques with Java implementations", Morgan Kaufmann Publishers, San Fransisco, CA (2000). 3.D. Pyle, "Data Preparation for Data Mining", Morgan Kaufmann, (1999) 4.Korth, Silbertz, Sudarshan, "Database Concepts", McGraw Hill Elmasri, Navathe, "Fundamentals of Database Systems", Addision Wesley

1	**Code of the subject**	BCCS-3103
2	**Title of the subject**	Information Security Systems
3	**Any prerequisite**	Computer Architecture, C/C++ Programming, Operating Systems Concepts, Computer Networks
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Saumya Bhadauria
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• This course provides a deep and comprehensive study of the security principles and practices of information systems. • To understand what the foundational theory is behind computer security and what are the common threats
8	**Brief Contents (module wise)**	Module 1: Overview of Information Security: confidentiality, integrity, and availability, User authentication, Information Security for Server Systems, Information Security for Client devices Module 2: Understanding the Threats: Malicious software (Viruses, trojans, rootkits, worms, botnets), Memory exploits (buffer overflow, heap overflow, integer overflow, format string) Module 3:Network Security: Network Intrusion detection and prevention systems, Firewalls, DNS security issues and defences, TLS/SSL, Internet Security Protocols and Standards Module 4: Information Security and Cryptography, Mathematics of Cryptography, Ciphers: Substitution and Transposition, Symmetric Encryption and Message Confidentiality, Integrity of Data, Hash Function, Digital Signature Module 5: Presentation and Discussion
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	• William Stallings and Lawrie Brown. 2014. *Computer Security: Principles and Practice* (3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA. • Behrouz A. Forouzan. 2007. *Cryptography &Amp; Network Security* (1 ed.). McGraw-Hill, Inc., New York, NY, USA. • M. Stamp, “Information Security: Principles and Practice,” 2st Edition, Wiley, ISBN: 0470626399, 2011. • M. E. Whitman and H. J. Mattord, “Principles of Information Security,” 4st Edition, Course Technology, ISBN: 1111138214, 2011.

1	**Code of the subject**	BCCS-3104
2	**Title of the subject**	Compiler Design
3	**Any prerequisite**	Basic course on Theory of Computation
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Santosh Singh Rathore
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• 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 such as a bottom-up SLR parser without using Yacc/Bison or any other compiler-generation tools.
8	**Brief Contents (module wise)**	**Module 1:**Front end of compilers: The structure of Compiler – Lexical analysis, Syntax analysis, LR parsers. **Module 2:**Intermediate code generation: Syntax Directed Definitions, Evaluation orders for syntax directed definitions, Syntax Directed, Translation schemes, Intermediate languages. **Module 3:**Object code generation: Storage organization, Stack allocation space, Access to non-local data on the stack, Heapmanagement, Issues in code generation, Design of code generator, Register allocation andassignment, Optimal code generation for expressions. **Module 4:**Code optimization: Basic blocks and flow graphs, Optimization of basic blocks, Principal sources of optimizations, Data flow analysis, Constant propagation, Partial redundancy elimination, Peepholeoptimizations. **Module 5:**Parallelizing compiler: Basic concepts and examples, Iteration spaces, Affine array indexes, Data reuse, Arraydata dependence.
9	**Contents for lab (If applicable)**	None
10	**List of text books/references**	1. Alfred V. Aho, Monica S.Lam, Ravi Sethi, Jeffrey D.Ullman, “Compilers : Principles, Techniques and Tools”, Second Edition, Pearson Education, 2008. 2. Randy Allen, Ken Kennedy, “Optimizing Compilers for Modern Architectures: A Dependence-based Approach”, Morgan Kaufmann Publishers, 2002. 3. Steven S. Muchnick, “Advanced Compiler Design and Implementation”, Morgan Kaufmann Publishers - Elsevier Science, India, Indian Reprint 2003. 4. Keith D Cooper and Linda Torczon, “Engineering a Compiler”, Morgan Kaufmann Publishers Elsevier Science, 2004. 5. V. Raghavan, “Principles of Compiler Design”, Tata McGrawHill Education Publishers, 2010.

1	**Code of the subject**	BCCS-3105
2	**Title of the subject**	Computer Graphics Lab
3	**Any prerequisite**	NIL
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr Debanjan Sadhya
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• Understand the need of developing graphics application. • Learn algorithmic development of graphics primitives like: line, circle, polygon etc. Learn the representation and transformation of graphical images and pictures.
8	**Brief Contents (module wise)**	1. Digital Differential Analyzer Algorithm. 2. Bresenham's Line Drawing Algorithm. 3. Midpoint Circle Generation Algorithm. 4. Ellipse Generation Algorithm. 5. Creating various types of texts and fonts. 6. Creating two dimensional objects. 7. Two Dimensional Transformations. 8. Coloring the Pictures. 9. Three Dimensional Transformations. 10. Curve Generation. 11. Simple Animations using transformations. 12. Key Frame Animation.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. "Computer Graphics", Udit Agarwal, *Katson Books*. "Essential Computer Graphics Techniques for Modeling, Animating, and Rendering Biomolecules and Cells: A Guide for the Scientist and Artist", Giorgio Luciano, *CRC Press*.

1	**Code of the subject**	BCCS-3106
2	**Title of the subject**	Systems Software Lab
3	**Any prerequisite**	Basic programming knowledge
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Debanjan Sadhya
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• To build an understanding on the design and implementation of different types of system software.
8	**Brief Contents (module wise)**	1. Implement a symbol table with functions to create, insert, modify, search, and display. 2. Implement pass one of a two pass assembler. 3. Implement pass two of a two pass assembler. 4. Implement a single pass assembler. 5. Implement a two pass macro processor 6. Implement a single pass macro processor. 7. Implement an absolute loader. 8. Implement a relocating loader. 9. Implement pass one of a direct-linking loader. 10. Implement pass two of a direct-linking loader. 11. Implement a simple text editor with features like insertion / deletion of a character, word, and sentence. 12. Implement a symbol table with suitable hashing
9	**Contents for lab (If applicable)**	N/A
10	**List of text books/references**	1. “System Software: An Introduction to Systems Programming”, Leland L. Beck, D. Manjula, *Pearson*. 2. “System Software”, J Nithyashri, *McGraw Hill Education*.

Semester-VI

1	**Code of the subject**	BCCS-3201
2	**Title of the subject**	Graph Theory
3	**Any prerequisite**	NIL
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Anuraj Singh
6	**Will this course require visiting faculty**	No
7	**Objectives of the subje about 50 words)**	➢ To develop ability to solve real life problems, translating them one form to another, using appropriate mathematical and computational techniques ➢ To prepare abstract and critical mathematical thinking, 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 the concepts to practical applications of computer science
8	**Brief Contents (module wise)**	**Module I**-Introduction to graphs, Paths and Circuits, Trees and Fundamental Circuits, Spanning Tree, Matrix Tree Theorem, Euler Graph, Hamiltonian Graph, Isomorphism **Module II**- Cut-sets and Cut vertices, Planar and Dual graphs, Embedding, Kurtowski Theorem, Euler Identity **Module III**- Matrix representation of Graphs, Coloring, Edge Coloring, Chromatic Number, Brooks Theorem, Five-color theorem, Matching **Module IV**- Directed graph, Underlying graph, Outdegree, in-degree, Connectivity, Orientation, Eulerian directed graphs, Hamilton directed graphs, Arborescence,Tournament, Acyclization **Module V**- Applications of Graph Theory: In Switching and Coding Theory, Electrical Network Analysis
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. DeoNarsingh, Graph Theory With Applications To Engineering And Computer Science, Prentice Hall of India, 1992 2. West, Douglas B., Introduction to Graph Theory, Pearson Education, 2002 3. Mott J.L., Kandel, A. and Baker T.P., Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall of India, 2001 4. ReinhardDiestel, Graph Theory, Springer International Edition, 2004

1	**Code of the subject**	BCCS-3202
2	**Title of the subject**	Machine Learning
3	**Any prerequisite**	Introductory courses on probability theory and linearalgebra. Knowledge of basic programming languages such as Python and Matlab.
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr Sunil Kumar
6	**Will this course require visiting faculty**	No
7	**Objectives of the subje about 50 words)**	After successful completion of this course, students will able to relate/understand/solve several day-to-day real-time with machine learning algorithms. The objective of this course is to familiarize the students with different machine learning algorithms ranging basic linear classifier/regression modelling problems to non-linear classification problem usingdeep-neural-network.
8	**Brief Contents (module wise)**	Module-I-Introduction to the course of machine learning (ML): What and Why? Types of machine learning problems: classification, regression, sequence modelling. Introducing prerequisites of ML. Module-II Linear classifier and classification problem, Gradient descent algorithm, Under-fitting vs Over-fitting problem, Training, Testing and Validation Process. Module-III Supervised vs unsupervised classification, Bayesian clas- sifier: decision boundaries; nearest neighbour methods, and support vector machine (SVM); Unsupervised learning: k-means and hier- archical clustering Module-IV Feature extraction and feature selection; Dimensionality reduction techniques: PCA, LDA and ICA. Module-V Introduction to Neural Networks: Modelling and applica- tions to logic gates. Back-propagation learning algorithm: training and testing Module-VI Introduction to Convolution neural network (CNN): AlexNet, VGG architectures. Introduction ro auto-encoder and generative adversarial networks (GAN) Mentioned in separate lab course for this subject
9	**Contents for lab (If applicable)**	
10	**List of text books/references**	1. Christopher Bishop. Pattern Recognition and Machine Learning, SecondEdition 2. Ethem Alpaydin, Introduction to Machine Learning, Second Edition 3. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e,2008.

1	**Code of the subject**	BCCS-3203
2	**Title of the subject**	Cloud Computing
3	**Any prerequisite**	No
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	Cloud computing is a scalable services consumption and delivery platform that provides on-demand computing service for shared pool of resources, namely servers, storage, networking, software, database, applications etc., over the Internet. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources, which can be rapidly provisioned and released with minimal management effort. This course will introduce various aspects of cloud computing, including fundamentals, management issues, security challenges and future research trends. This will help students (both UG and PG levels) and researchers to use and explore the cloud computing platforms.
8	**Brief Contents (module wise)**	Module I: • Introduction to Cloud Computing Module II: • Introduction to Parallel and Distributed Computing Module III: • Cloud Computing Architecture Module IV: • Service Management in Cloud Computing Module V: • Data Management in Cloud Computing Module VI: • Virtualization & Resource Management in Cloud Module VII: • Cloud Security Module VIII: • Open Source and Commercial Clouds, Cloud Simulator Module IX: Research trend in Cloud Computing, Fog Computing
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	1. Cloud Computing: Principles and Paradigms, Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley,2011 2. Enterprise Cloud Computing - Technology, Architecture, Applications, GautamShroff, Cambridge University Press, 2010 3. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010 4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley- India,2010 5. Mastering in Cloud Computing, Editors: RajkumarBuyyaet. al.

1	**Code of the subject**	BCCS-3204
2	**Title of the subject**	Machine Learning Lab
3	**Any prerequisite**	Programming languages: Python, Matlab, etc. 4
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr Sunil Kumar
6	**Will this course require visiting faculty**	No
7	**Objectives of the subje about 50 words)**	After successful completion of this lab course on machine learning, students will able accomplished the following objectives: • Getting familiarize with one of the most popular programming languageinthefieldofdeep-learningi.e.,Python. • Visualization of regression and classification problems with data. • Feature extraction and feature reduction: what andwhy? • Understanding of how machine mimics human brain with simpleexamples.
8	**Brief Contents (module wise)**	Module-1-Introduction to Python/Matlab and their various modules. Python libraries: Tensorflow, Anaconda, keras, and etc. Module-2 Implementation of regression problem: line-fitting and curve-fitting with Under-fitting and over-fitting constraints Module-3 Implementations of linear classifier, Bayesian classifier, and k-NN classifier Module-4 Dimensionality reduction techniques: PCA, LDAand Locality preserving projection(LPP). Module-5 Implementations of logic gates (AND/OR/NOR/XOR) using perceptron-based methods and why XOR can not be imple- mented using single layerperceptron. Module-6 Hand-written classification using convolution neural net- work (CNN). Understanding of AexNet and VGG network using Python
9	**Contents for lab (If applicable)**	
10	**List of text books/references**	1.Programming in Python 3: A Complete Introduction to the Python Language by MarkSummerfield 2.Pratap, Rudra. Getting Started with MATLAB 5: A Quick Intro-ductionforScientistsandEngineers.OxfordUniversityPress 3. http://www.deeplearningbook.org Christopher Bishop. Pattern Recognition and Machine Learning, SecondEdition

1	**Code of the subject**	BCCS-3205
2	**Title of the subject**	Cloud Computing Lab
3	**Any prerequisite**	No
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	Cloud computing is a scalable services consumption and delivery platform that provides on-demand computing service for shared pool of resources, namely servers, storage, networking, software, database, applications etc., over the Internet. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources, which can be rapidly provisioned and released with minimal management effort. This course will introduce various aspects of cloud computing, including fundamentals, management issues, security challenges and future research trends. This will help students (both UG and PG levels) and researchers to use and explore the cloud computing platforms.
8	**Brief Contents (module wise)**	Module I: • A Case Study on Amazon EC2 Module II: • A Case Study on Google Cloud Module III: • A Case Study on Microsoft Assure Module IV: • A Case Study on IBM Cloud Module V: • A Case Study on Open Source CLoudSim Simulator and Hands on Module VI: • A Case Study on Open Source FogSim Simulator and Hands on Module VII: • A Case Study on Commercial Cloud Aneka. Module VIII: • A Case Study on Current/emerging Research Topics
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	6. Cloud Computing: Principles and Paradigms, Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley,2011 7. Enterprise Cloud Computing - Technology, Architecture, Applications, GautamShroff, Cambridge University Press, 2010 8. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010 9. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley- India,2010 10. Mastering in Cloud Computing, Editors: RajkumarBuyyaet. al.

Semester-VII

1	**Code of the subject**	BCCS-4101
2	**Title of the subject**	Modeling and Simulation
3	**Any prerequisite**	Engineering Mathematics and Probability & Statistics
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr Ajay Kumar
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To teach the application of mathematics and statistics in real life problems.
8	**Brief Contents (module wise)**	Introduction: Concept of a system, System Environment, Modeling and Simulation of Real world problems, Classification of Models and examples, Static and Dynamic models, Principles used in modeling System Studies: Subsystems, A Corporate models, Block diagram of modeling and simulation, System Analysis, System Design Mathematical Models: Mathematical models in population dynamics, Epidemic Models, some mathematical modeling in Biology and Medicine Innovation diffusion models in marketing System Simulation: The technique of simulation, the Monte Carlo Method, Types of system simulation, Continuous and Discrete time Simulation, Probability Concepts in Simulation: Stochastic variables, Discrete and continuous probability distributions, Measures of probability functions, Random numbers generation, Stochastic Processes: Poisson Process, Markov Process, Queuing Theory, Reliability. Linear programming in Simulation: Introduction, Transportation problem, Assignment problem and other simulation techniques in Operation research. Software in System Simulation: Numerical computation technique for continuous and discrete models (MATLAB)
9	**Contents for lab (If applicable)**	Given separately.
10	**List of text books/references**	1. Banks, J., Carson, I. I., Nelson, B. L., &Nicol, D. M. (2005). Discrete-event system simulation. Pearson. 2. Kishor S Trivedi, Probability & Statistics With Reliability, Queuing And Computer Science Applications, 2nd Ed, Wiley. 3. Geoffrey Gordon, System Simulation, Prentice-Hall.

1	**Code of the subject**	BCCS-4102
2	**Title of the subject**	Big Data Analytics
3	**Any prerequisite**	Basic Mathematics, Data Structures, Algorithms, Computer Architecture, Operating System, and Database Management Systems
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Pramod Kumar Singh
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	➢ An in-depth understanding of terminologies and the core concepts behind big data problems, applications, systems and the techniques ➢ An introduction to some of the most common Big Data frameworks and Big Data Streaming Platforms.
8	**Brief Contents (module wise)**	Introduction to Big Data: Why Big Data and Where did it come from, Characteristics of Big Data- Volume, Variety, Velocity, Veracity, Valence, Value, Challenges and applications of Big Data. Introduction to Enabling Technologies for Big Data, Introduction to Big Data Stack, Introduction to some Big Data distribution packages. Introduction to Big Data Platforms, Overview of Apache Spark, HDFS, YARN, Introduction to MapReduce, MapReduce Programming Model with Spark, MapReduce Example: Word Count, Page Rank etc. Introduction to Big Data Storage Platforms for Large Scale Data Storage, CAP Theorem, Eventual Consistency, Consistency Trade-O-s, ACID and BASE, Introduction to Zookeeper and Paxos, Introduction to Cassandra, Cassandra Internals, Introduction to HBase, HBase Internals. Introduction to Big Data Streaming Platforms for Fast Data, Introduction to Big Data Streaming Systems, Big Data Pipelines for Real-Time computing, Introduction to Spark Streaming, Kafka, Streaming Ecosystem. Introduction to Big Data Applications (Machine Learning), Overview of Big Data Machine Learning, Mahout Introduction, Big Data Machine Learning Algorithms in Mahout- kmeans, Naïve Bayes etc. 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. Introduction to Big Data Applications (Graph Processing), Introduction to Pregel, Introduction to Giraph, Introduction to Spark GraphX.
9	**Contents for lab (If applicable)**	No lab is associated with this course.
10	**List of text books/references**	1. Big Data Science & Analytics: A Hands-On Approach, ArshdeepBahga 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**	BCCS-4103
2	**Title of the subject**	Fundamentals of Internet of Things
3	**Any prerequisite**	BCCS-3202 -Machine Learning
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Pinku Ranjan
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	We are surrounded by millions of things and devices. Internet of Things (IoT) is a technological need to interconnect all such devices, things with us anywhere, anytime. This course attempts to address the paradigm shift in technologies, standards, tools needed to achieve the interoperability and thereby develop applications. ➢ Understand the basics of IoT and its application sectors. ➢ Understand M2M and IoT ➢ Understand and become proficient in IoT platforms ➢ Understand and apply IoT protocols appropriately ➢ Design and develop IoT based applications
8	**Brief Contents (module wise)**	**INTRODUCTION AND CONCEPTS OF IOT:** Introduction to IOT, definition and characteristics of IOT, Overview of the syllabus;Architecture of Internet of Things, Physical and logical design of IOT, IOT enabling technologies, IoT levels and deployment templates; Domain specific IOTs, home automation, cities, environment, Domain specific IOTs, Energy, retail, agriculture, industry, health and lifestyle **IOT AND M2M COMMUNICATION:** M2M, diff. between IoT and M2M, ETSI M2M Architecture, system architecture;ETSI M2M SCL resource structure, Security in ETSI M2M framework, SDN and NFV for IoT, IoT system management, need for IoT system management;SNMP, Network operator requirements, NETCONF-YANG, IoT management withNETCONF YANG, IoT Design methodology case study on IoT for Weather Monitoring **IoT PLATFORMS:** Int. to Hardware used for IoT:Microcontrollers, Microprocessors, SoC, Sensors;Int. to Arduino, Pi, Spark, Intel Galileo **IoT TECHNICAL STANDARDS AND PROTOCOLS:** RF Protocols: RFID, NFC;IEEE 802.15.4: ZigBee, Z-WAVE, THREAD; Bluetooth Low Energy (BLE), IPv6 for Low Power and Lossy Networks (6LoWPAN) and Routing Protocol for Low power and lossy networks (RPL);CoAP ,XMPP, Web Socket, AMQP, MQTT, WebRTC, PuSH;Architectural Considerations in Smart Object Networking **DEVELOPING INTERNET OF THINGS:** IoT platforms design methodology, IoT Physical devices and endpoints;IoT Systems: Logical design using Python, IoT physical servers and cloud offerings
9	**Contents for lab**	NA
10	**List of text books/references**	1.Arshdeep Bahga, Vijay Madisetti, Internet of Things, A Hands -on Approach, 1st Ed. 2015, University Press 2.Oliver Hersent, David Boswarthick, Omar Elloumy, The Internet of Things, 2015 3. Michael Miller, "The Internet of Things, How Smart TVs, Smart Cars, Smart Homes, Smart Cities are changing the World, 1st ed. ,2015, Pearson , 4. Raj Kamal, Internet of Things Architecture and Design Principles, McGraw Hill Education (India) Private Lim.,2017

1	**Code of the subject**	BCCS-4104
2	**Title of the subject**	Simulation Lab
3	**Any prerequisite**	Basic knowledge of Mathematics, statistics, excel
4	**L-T-P**	0-0-2
5	**Name of the proposer**	Dr Ajay Kumar
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To teach the applications of mathematics and statistics
8	**Brief Contents (module wise)**	Monte Carlo simulation a) Finding value of pi b) Area under the curve c) Double integration d) Multiple integration e) Area of irregular shaped body Discrete Event simulation a) Tossing a coin/dice simulation b) Singer server queue c) Multiple server queues d) Inventory problems Other Tools a) Computer Generation of Random Numbers b) Testing Random Number Generators c) Fitting a statistical distribution d) Chi-square goodness-of-fit test e) One-sample Kolmogorov-Smirnov test f) Test for Standard Normal Distribution
9	**Contents for lab (If applicable)**	Written above
10	**List of text books/references**	1. Banks, J., Carson, I. I., Nelson, B. L., &Nicol, D. M. (2005). Discrete-event system simulation. Pearson. 2. Kishor S Trivedi, Probability & Statistics With Reliability, Queuing And Computer Science Applications, 2nd Ed, Wiley. 3. Geoffrey Gordon, System Simulation, Prentice-Hall.

1	**Code of the subject**	BCCS-4105
2	**Title of the subject**	Colloquium
3	**Any prerequisite**	
4	**L-T-P**	0-0-4 (2 credit course)
5	**Name of the proposer**	Dr. W. Wilfred Godfrey
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To instill the ability to identify skills and gain practical work experience ➢ To provide an opportunity to observe and contribute in the workplace ➢ To take ownership and responsibility of a project assignment, given by a designated manager/supervisor ➢ To provide networking opportunities with other members of the organization ➢ To offer performance feedback and mentorship throughout the internship
8	**Brief Contents (module wise)**	At the end of their internship work, the students should demonstrate: • Considerably more in-depth knowledge of the project assignment, including deeper insight into current development work and future scope for enhancement. • Deeper knowledge of tools and techniques used in the research/development work at the organisation. • The capability to contribute to development work through their creative, scientific endeavours at the organisation. • The capability to clearly present the problem and discuss the conclusions as well as the knowledge and arguments that form the basis for these findings in written and spoken English.
9	**Contents for lab (If applicable)**	Nil
10	**List of text books/references**	

Semester-VIII

1	**Code of the subject**	BCCS-4999
2	**Title of the subject**	Major Project
3	**Any prerequisite**	Academic honesty, ethics and a deeper understanding of the topic under research
4	**L-T-P**	0-0-30
5	**Name of the proposer**	Dr. K. K. Pattanaik
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	To develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.
8	**Brief Contents (module wise)**	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. Specific learning outcomes for a Major project are for the student to demonstrate: • Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into hardware/software application development work. • The capability to create, analyse and critically evaluate different technical/architectural solutions. • The capability to clearly present and discuss theconclusions as well as the knowledge and arguments that form the basis for the learning outcome in written and spoken English. • A consciousness of the ethical aspects of research and development work.
9	**Contents for lab (If applicable)**	No
10	**List of text books/references**	

Electives (Computing and Data Sciences)

1	**Code of the subject**	BCCS-9101
2	**Title of the subject**	Convex Optimization Techniques
3	**Any prerequisite**	Knowledge in Linear Algebra & Real Analysis
4	**L-T-P**	2-1-0
5	**Name of the proposer**	Jeevaraj S
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ To present the basic theory of such problems, concentrating on results thatare useful in computation. ➢ To give students the background required to use the methods in their ownresearch or engineering workTo study of codes and the art of writing and solving them. ➢ To give students a thorough understanding of how such problems aresolved, and some experience in solving them.
8	**Brief Contents (module wise)**	Basic facts of maxima & minima & convex optimization. Important classes of convex optimization problems. Convex sets & convex functions Differentiable convex functions Sub differential of a convex. Saddle point Conditions. Karush-kuhn-Tucker Conditions Lagrangian duality and examples. Strong duality & consequences. Duality in connection with Linear Programming. Linear programming, basics & examples. Basic results and the fundamental theorems of linear programming. Simplex method. Introduction to interior point methods. Predictor-corrector method. Short step path following method. Semi definite programming
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1.“Stories about Maxima & Minima” by V.M. Tikhomirov. Publisher: American MathematicalSociety. 2.“Convex Optimization” by S. Boyd. Publisher: Cambridge University Press 3. “Convex Analysis and Minimization Algorithms” By J.B.Hiriat-Uruty&Lemarechal, Publisher:Springer. 4.“Convex Analysis” by R.T.Rockafellar, Publisher: Princeton.

1	**Code of the subject**	BCCS-9102
2	**Title of the subject**	Quantum Computing (Elective)
3	**Any prerequisite**	Knowledge of quantum mechanics
4	**LTP (Lecture-Tutorial-Practical) and Credits Structure**	3-0-0 3 credits
5	**Name of the proposer**	Dr. Pankaj Srivastava
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	A quantum computer is any device for computation that makes direct use of distinctively quantum mechanical phenomena, such as superposition and entanglement to perform operations on data. In a classical computer, information is stored as bits; in a quantum computer, it is stored as qubits. The basic principle of quantum computation is that the quantum properties can be used to represent and structure data and that quantum mechanisms can be devised and built to perform operations with this data.
8	**Brief Contents (module wise)**	**UNIT-I-Qubits and quantum states : C**lassical & quantum information, qubits, quantum computing&laws of physics, quantum information, quantum computers, vector spaces, postulates of quantum mechanics, linear combinations, basis & dimensions, inner products, Cauchy-schwart triangle inequalities. **UNIT-II- M*atrices & Operators*** - Pauli operators, outer products & matrix representation, Hermitian, unitary & normal operators, eigenvalues and eigen vectors, characteristic equation, trace of an operator, expectation value of an operator, projection operators**.** **UNIT-III-Quantum Gates and Circuits:** classical logic gates circuits, one qubit quantum gates, Hadamard gate, two qubit quantum gates- the CNOT gate, three qubit quantum gates- The Fredkin gate, The Toffoli gate, quantum circuits, universal quantum gates. Entanglement, exchange of information using entangled particles, Bell's states, Bipartite systems and the Bell basis. **UNIT-IV-Quantum Algorithms:** classical to quantum Turing machines, computational complexity and entanglement, classes of quantum algorithms, Deutsch's algorithm, The Deutsch-Josza Algorithm, Shor's Algorithm, Grover's Algorithm, Simon's algorithm, quantum search algorithm. **UNIT-V-Quantum cryptography:** information content in a signal, entropy and Shannon's information theory, deterministic versus probabilistic photon behavior, state description, superposition and uncertainty, measurement of superposition states, an augmented probabilistic model, a photon coincidence experiment, BB84-emergence of quantum cryptography.
9	**Contents for lab (If applicable)**	1. Implementation of half adder using quantum gates. 2. Implementation of half substractor using quantum gates. 3. Implementation of full adder using quantum gates. 4. Implementation of full substractor using quantum gates. 5. Implementation of encoder/multiplexer using quantum gates.
10	**List of text books/references**	1. Quantum Mechanics- Schiff 2. Quantum computing- Mika Hirvensalo 3. Quantum Computation and Quantum Information-Michael Nielsen & Chuang 4. An introduction to quantum computing- Phillip Kaye et al. 5. Lectures on Quantum Information- Dagmar Brub, GerdLeuchs 6. Quantum Computing- J. Stolze, Dieter Suter

1	**Code of the subject**	BCCS-9103
2	**Title of the subject**	Complexity and Advanced Algorithm
3	**Any prerequisite**	Design and Analysis of Algorithms
4	**L-T-P**	3-0—0
5	**Name of the proposer**	Prof. K. V. Arya
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	Learn to analyze iterative and recursive algorithms for use of resources (time, memory, parallelism, bandwidth, randomness, etc.). Develop fluency to choose and implement efficient algorithms for numeric, combinatorial, and geometric problems. Learn basic concepts and terminology in computability and computational complexity.
8	**Brief Contents (module wise)**	Module-I:Max Flow Problem Module-II:Theory of NP- Hard and NP-Complete Problems Module-III:Parallel graph algorithms Module-IV:Parallel Algorithms Module-V:Probabilistic Algorithms & Randomized Algorithms
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. T.H. Cormen, C.E.Leiserson and R.L. Rivest, Introduction to Algorithms, PHI 2. R. Motwani and P.Raghavan, Randomized Algorithms, Cambridge University Press 3. D. Friedman and Y. Harel, The spirit of computing, Addison-wesley 4. S. G. Akl, The Design and Analysis of Parallel Algorithms, Prentice Hall International

1	**Code of the subject**	BCCS-9104
2	**Title of the subject**	Reconfigurable Computing
3	**Any prerequisite**	Digital design fundamentals, computer architecture and organization, programming language C
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Santosh Singh Rathore
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• To investigate the state-of-the-art in reconfigurable computing both from a hardware and software perspective. • To understand both how to architect reconfigurable systems and how to apply them to solving challenging computational problems.
8	**Brief Contents (module wise)**	**Module I:**Introduction to Reconfigurable Computing and digital design fundamentals **Module II:** FPGA architectures, CAD for FPGS: overview, LUT mapping, timing analysis, placement and routing. **Module III:** Reconfigurable devices-from fine-grained to coarse-grained devices, Reconfiguration modes and multi-context devices, Dynamic reconfiguration, Compilation from high level languages. **Module IV:** System level design for reconfigurable systems; heuristic temporal partitioning and ILP-based temporal partitioning. Behavioural synthesis, Reconfigurable example systems' tool chains. **Module V:** Reconfigurable Computing Applications: Molecular Dynamics, Image processing, Video processing, Bioinformatics, Cryptography, Fault tolerant systems **Module VI:** Advanced Topics: Dynamic Reconfiguration, Partial Reconfiguration
9	**Contents for lab (If applicable)**	None
10	**List of text books/references**	1. Scott Hauck, André DeHon, “Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation”. 2008. 2. Christophe Bobda,“Introduction to Reconfigurable Computing: Architectures, Algorithms, and Applications”. 2007.

1	**Code of the subject**	BCCS-9105
2	**Title of the subject**	Parallel & Concurrent Programming
3	**Any prerequisite**	Advanced Computer Architecture, C/C++ Programing
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	This course is about writing effective programs to harness the unprecedented power provided by modern parallel computers, so that the programs attain the highest possible levels of performance the machines are capable of. The parallel computers we focus on include multi-core processors as well as clusters and supercomputers made from them. The programming systems and methodologies we learn will include OpenMP, MPI and CUDA. However, the focus of the course is not so much on the mechanics of these programming systems as on how to use them to attain and improve high performance. This performance orientation pervades throughout the course, and is enhanced by several case studies, small enough to understanding the lecture format yet complex enough to illustrate performance issues and trade-offs. The course also teaches an adequate analytical framework for understanding performance, including performance models, scalability analysis, and iso-efficiency.
8	**Brief Contents (module wise)**	**Module I:** Introduction to Parallel & Distributed Systems: Parallel Programming Paradigms, Parallel Architecture, Principals of Parallel Programming , Models of Parallel Computation, Complexity, PRAM, Memory Consistency & Performance Issues , Memory Consistency & Performance Issues , Shared Memory & Message Passing. **Module II:** OpenMP: Introduction to OpenMP, Work Sharing, Scheduling, Synchronization, Tasks, Environment Variables and Run Time Library Routines, Other Clauses and Directives **Module III:** MPI: Basics of MPI, Cost Model, One-sided/two-side communication, Hybrid programming (MPI + OpenMP) **Module IV:** Introduction to CUDA: GPU architecture, high performance computing on GPUs, parallel algorithms, CUDA libraries, and applications of GPU computing. **Module V:**Introduction to design of parallel algorithms and hands on
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	1. OpenMP Specification Documents, http://openmp.org/wp/openmp-specifications/ 2. Chandra et al, “Parallel Programming in OpenMP”, Morgan Kaufmann. 3. Chapman, Jost, and van der Pas, “Using OpenMP: Portable Shared Memory Parallel Programming”, MIT Press. 4. MPI 3.1 report (https://www.mpi-forum.org/docs/mpi-3.1/mpi31-report.pdf) 5. Programming Massively Parallel Processors (3rd Edtion)

1	**Code of the subject**	BCCS-9106
2	**Title of the subject**	Program Analysis Verification and Testing
3	**Any prerequisite**	Discrete Mathematics, Data Structures, Theory of Computation
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Saumya Bhadauria
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	To give overview of the theoretical fundamentals of the subject also to provide information of some of the modern verification and testing tools.
8	Brief Contents (module wise)	Module I: Dataflow Analysis, Interprocedural Analysis: functional, call-string and graph reachability based approaches Module II: Abstract Interpretation, Weakest Precondition, Floyd-Hoare Logic, Separation Logic; Module III: Software Model Checking: symbolic execution, state-space reduction, state-less model checking, counter-example guided abstraction refinement, model checking of concurrent programs Module IV: Program Testing: program testing basics, automatic test-case generation, directed testing
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	• EdsgerWybeDijkstra. A Discipline of Programming. Prentice Hall PTR, Upper Saddle River, NJ, USA, 1997. • Michael Huth and Mark Ryan. Logic in Computer Science: Modelling and Reasoning about Systems. Cambridge University Press, New York, NY, USA, 2004. • Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman. Compilers: Principles, Techniques, and Tools (2nd Edition). Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 2006.

1	**Code of the subject**	BCCS-9107
2	**Title of the subject**	Randomized Algorithms
3	**Any prerequisite**	Mathematics, Algorithms, Data Structures, C Programming
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	In this course, firstly the student will be taught the probability tools required to design and analyze a randomized algorithm. The emphasis will be on strengthening the analytical skills of the student so that he can independently design or analyze a randomized algorithm. For this purpose, the student will be exposed to a variety of randomized algorithms during the course.
8	**Brief Contents (module wise)**	**Module I:** • Probability tools: Revision of elementary probability theory, Random variable, Expected value and variance of a random variable. **Module II:** • Linearity of expectation, Independence of random variables, Conditional probability and expectation, Markov Inequality, Chernoff bound, Chebyshev Inequality, Method of bounded difference (Martingales). **Module III:** • Topics of Randomized algorithms : Analysis of randomized quick sort or randomized median finding algorithm, Backward Analysis with applications in computational geometry, Balanced allocations, Principle of deferred decision, Graph algorithms (minimum spanning tree, all pairs shortest paths). **Module IV:** • Average case analysis of algorithms, Electrical resistance and cover time of graphs, Fingerprinting and Algebraic Techniques, Probabilistic methods, Hashing with worst case O(1) search time, and a large number of specific randomized algorithms
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	1. Randomized algorithms by Rajeev Motwani and PrabhakarRaghavan, Cambridge press (Indian edition available). 2. Introduction to Probability theory and Its Applications (volume 1) by William Feller (Indian edition available). 3. Probabilistic Methods by NogaAlon and Joel Spencer, Wiley Interscience.

1	**Code of the subject**	BCCS-9108
2	**Title of the subject**	Semantics of Programming Languages
3	**Any prerequisite**	C Programming
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. SaumyaBhadauria
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	To understand and apply formal semantic descriptions of programming languages and other languages, in operational semantics.
8	Brief Contents (module wise)	Module I: Syntax versus semantics, Use of formal semantics, Formal versus informal semantics. Operational, denotational and axiomatic approaches Module II: Adequacy, full abstraction and completeness, Properties of semantic descriptions. Compositionality and structural induction. Module III: Structural operational semantics. Natural semantics. Techniques for describing the operational semantics of programming language construct. Applications of operational semantics.
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	• Hennessy, M. (1990). The Semantics of Programming Languages. Wiley • G. Winskel, The Formal Semantics of Programming Languages: an introduction, MIT Press, 1993. • Pierce, B. C. (2002) Types and Programming Languages. MIT Press.

1	**Code of the subject**	BCCS-9109
2	**Title of the subject**	Game Theory
3	**Any prerequisite**	Basic knowledge of Engineering Mathematics and Statistics
4	**L-T-P**	2-1-0
5	**Name of the proposer**	Dr Ajay Kumar
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To teach the applications of game theory, auction and equilibrium.
8	**Brief Contents (module wise)**	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.
9	**Contents for lab (If applicable)**	NO
10	**List of text books/references**	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**	BCCS-9110
2	**Title of the subject**	Scientific Computing and Numerical Methods
3	**Any prerequisite**	Mathematics-I, Mathematics-II
4	**L-T-P**	2-1-0
5	**Name of the proposer**	Anuraj Singh
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ To demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems. ➢ To apply numerical methods to obtain approximate solutions to mathematical problems. ➢ To analyse and evaluate the accuracy of common numerical methods. ➢ To write efficient, well-documented MATLAB code and present numerical results in an informative way.
8	**Brief Contents (module wise)**	**Module-I:** Introduction, Significant Digits, Inherent Error, Rounding Error, Truncation Error, Absolute and Relative Error, Error Propagation. **Module-II:** Bisection Method, False Position Method, Newton-Raphson Method, Convergence of Bisection, Newton-Raphson'sand False Position Methods, Fixed Point Iterative Method, Gauss Elimination Method, Gauss-Jordan Method, Gauss-Seidel Method, Convergence of Iterative Methods. **Module-III:** Finite Difference Operators and Their Relationships, Difference Tables, Newton Forward and Backward Interpolation Formula, Lagrange Interpolation Formula, DividedDifference Operator, Newton Divided Interpolation Formula. **Module-IV:** Differentiation Continuous Functions, Differentiation of Tabulated Functions, Higher Order DerivativesNewton-Cotes Integral Formula, Trapezoidal Rule, Simpson's Rules, Boole's Rule and Weddle's Rule, Romberg Integration **Module-V:** Taylor Series Method, Picard's Method, Euler and Modified Euler Method, Runge-KuttaMethods, Milne's Method, Finite Differences Approximations of Partial Derivatives, Solution of Laplace Equation(Elliptic)By Standard 5 – Point Formula, Solution of One Dimensional Heat Equation(Parabolic) By Bender-Schmidt Method, Crank-Nicolson Method, Solution of One Dimensional Wave Equation(Hyperbolic) by Iterative Method.
9	**Contents for lab (If applicable)**	Yes
10	**List of text books/references**	1. Balagurusamy, E., Numerical Methods, Tata McGraw Hill Education Pvt. Ltd., 1999. 2. Sastry, S. S., Introductory Methods of Numerical Analysis, PHI Learning Pvt Ltd., 2012. 3. Jain, M. K., Iyengar, S.R.K and Jain, R.K, Numerical Methods for Scientific and Engineering computation, Wiley Eastern Ltd., 1985.

1	**Code of the subject**	BCCS-9111
2	**Title of the subject**	Advanced Competitive Programming
3	**Any prerequisite**	Knowledge of Programming language (C/C++/Java), Basic Data structure and algorithm course
4	**L-T-P**	1-0-4
5	**Name of the proposer**	Dr. Santosh Singh Rathore
6	**Will this course require visiting faculty**	Yes
7	**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
8	**Brief Contents (module wise)**	**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 logn) Sorting, Binary Searching, Heaps (priority queue) **Module II:** Advance Data Structure: Disjoint Set Union, Segment Trees, Binary Index Tree (Fenwick tree), Trees traversals, Fundamental of Dynamic Programming, tree dynamic programming **Module III:** GraphAlgorithms: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. **Module IV:** Modular arithmetic including division, inverseAmortized Analysis, Divide and Conquer, Advanced Dynamic Programming problems, Sieve of Eratosthenes 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)
9	**Contents for lab (If applicable)**	The practice of theoretical concepts discussed in the class.
10	**List of text books/references**	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. NarasimhaKarumanchi, "Data Structures and Algorithms made easy", CareerMonk Publications; Fifth edition, 2016.

1	**Code of the subject**	BCCS-9112
2	**Title of the subject**	Big Data and Cloud Computing
3	**Any prerequisite**	Data Structure, Algorithms, Database Management Systems
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Debanjan Sadhya
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• Give a comprehensive view on the world of Cloud Computing and Big Data. • Provide an in-depth understanding of terminologies and the core concepts behind big data problems, applications, systems and the techniques that underlie today big data computing technologies. • Provide an introduction to some of the most common frameworks such as Apache Spark, Hadoop and MapReduce.
8	**Brief Contents (module wise)**	**Module I**: Introduction to Big Data: Why Big Data and where did it come from? Characteristics of Big Data- Volume, Variety, Velocity, Veracity, Valence, Value,Challenges and applications of Big Data. **Module II**: Introduction to Enabling Technologies for Big Data,Introduction to Big Data Stack,Introduction tosome Big Data distribution packages. **Module III**: Introduction to Big Data Platforms,Overview of Apache Spark, HDFS, YARN,Introduction toMapReduce,MapReduce Programming Model with Spark,MapReduce Example: Word Count, PageRank etc. **Module IV**: Introduction to Big Data storage platforms for large scale data storage,CAP theorem, Eventualconsistency, Consistency trade-offs, ACID and BASE,Introduction to Zookeeper and Paxos,Introduction to Cassandra, Cassandra internals,Introduction to HBase, HBaseinternals. **Module V**: Introduction to Big Data streaming platforms for fast data,Introduction to Big Data streamingsystems,Big Data pipelines for real-time computing,Introduction to Spark streaming,Kafka,Streamingecosystem. **Module VI**: Introduction to Big Data applications (Machine Learning),Overview of Big Data Machine Learning,Mahout introduction,Big Data machine learning algorithms in Mahout- kmeans, Naïve Bayes etc. **Module VII**: 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.
9	**Contents for lab (If applicable)**	N/A
10	**List of text books/references**	1."Big-Data Analytics and Cloud Computing: Theory, Algorithms and Applications", M. Trovati, R. Hill, A. Anjum,S.Y. Zhu, L. Liu, *Springer*. 2."Big-Data Analytics for Cloud, IoT and Cognitive Computing", Kai Hwang, Min Chen,*Wiley*. 3. "Big Data Computing" (NPTEL Course), Rajeev Misra. (https://nptel.ac.in/courses/106104189/)

Electives (Networks and Distributed Processing)

1	**Code of the subject**	BCCS-9113
2	**Title of the subject**	Data Analytics
3	**Any prerequisite**	BCCS-3202-Machine Learning
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Pinku Ranjan
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ Learn about the basics of data Science and to understand the various supervised and unsupervised learning techniques. ➢ Bring together several key technologies used for manipulating, storing, and analyzing big data from advanced analytics perspectives. ➢ Realize Hadoop architecture and implementation of MapReduce App..
8	**Brief Contents (module wise)**	**INTRODUCTION TO DATA SCIENCE:** Introduction of Data Science, Basic Data Analytics using R, R Graphical User Interfaces; Data Import and Export, Attribute and Data Types, Descriptive Statistics, Exploratory Data Analysis, Visualization Before Analysis, Dirty Data, Visualizing a Single Variable, Examining Multiple Variables, Data Exploration Versus Presentation; Statistical Methods for Evaluation, Hypothesis Testing, Difference of Means, Wilcoxon Rank-Sum Test, ANOVA **ADVANCED ANALYTICAL THEORY AND METHODS:** Overview of Clustering, K-means, Use Cases, Overview of Method, Perform a K-means Analysis using R; Classification, Decision Trees, Overview of a Decision Tree, Decision Tree Algorithms, Evaluating a Decision Tree; Decision Tree in R, Bayes Theorem, Naïve Bayes Classifier, Smoothing, Naïve Bayes in R **ADVANCED ANALYTICS TECHNOLOGY& TOOLS:** Analytics for Unstructured Data, Use Cases, MapReduce, Apache Hadoop, Hadoop Ecosystem, Pig, Hive, Hbase, Mahouth, NoSQL, SQL Essentials; Joins, Set Operations, Grouping Extensions, In-Database Text Analysis, SQL, Window Functions, User defined Functions, Ordered Aggregates, MADlib **HADOOP DISTRIBUTED FILE SYSTEM ARCHITECTURE:** HDFS Architecture, HDFS Concepts, Blocks; NameNode, Secondary NameNode, DataNode, HDFS Federation, HDFS High Availability, Basic File System Operations; Data Flow, Anatomy of File Read, Anatomy of File Write, Anatomy of a MapReduce Job Run **PROCESSING YOUR DATA WITH MAPREDUCE:** Getting to know MapReduce, MapReduce Execution Pipeline, Runtime Coordination and Task Management; MapReduce Application, Hadoop Word Count Implementation; Installing and Running Pig, Hbase Versus RDBMS, Installing and Running ZooKeeper
9	**Contents for lab**	NA
10	**List of text books/references**	1. D. Dietrich, B. Heller& Beibei Yang, Data Science &Big Data Analytics: Discovering, Analyzing, Visualizing Presenting Data, EMC, 2015, Wiley. 2.BirisLublinsky, Kevin T. Smith and Alexey Yakubovich, Professional Hadoop Solutions", Reprint 2014, Wiley. 3. tephenMarsland, "Machine Learning – An Algorithmic Perspective", , Taylor& Francis Group, Second Edition, 2015, Chapman & Hall / CRC Press 4. Nathan Marz, James Warren, "Big Data-Principles and best practices of scalable real-time data systems", Edition 2015, DreamTech Press. 5. Tom White, "Hadoop: The Definitive Guide", 4th Edition, 2015, O'Reilly,

1	**Code of the subject**	BCCS-9201
2	**Title of the subject**	Queuing Theory and Data Networks
3	**Any prerequisite**	Basic knowledge of Engineering Mathematics and Statistics
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr Ajay Kumar
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To teach the applications of queuing theory related to computer networks.
8	**Brief Contents (module wise)**	Basics of Probability and Statistics, Random processes- Introduction, classification, Stationary process – Wide Sense Stationary Strict Sense Stationary, Markov Process , Markov Chain, Problems based on Markov Process. Transition probabilities, Limiting distributions, Poisson Process - Properties, Poisson Process - Problems Queuing system – introduction, Markovian Models, Birth and Death Process, Little's Formula, M/M/1, Infinite Capacity, M/M/1, Finite Capacity, M/M/c, Infinite Capacity, M//M/c, Finite Capacity and finite population, M/M/∞ queue. Non Markovian queues- M/G/1 queue, GI/M/1 queue, GI/M/m queue, GI/G/1 queue, M/G/m queue, GI/G/m queue, Pollaczek- Khinchine formula. Priority queues-Queues with preemption, queues with time dependent priorities. Series queues, Open Networks, Closed Networks, batch service, batch arrival.
9	**Contents for lab (If applicable)**	NO
10	**List of text books/references**	1. K. S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications, John Wiley and Sons, 2nd edition, 2002. 2. A.O. Allen, Probability, Statistics and Queuing Theory with Computer Applications, Elsevier, 2nd edition, 2005. 3. Srivastava, H. M., &Kashyap, B. R. K. (1982). Special functions in queuing theory and related stochastic processes. ACADEMIC PRESS.

1	**Code of the subject**	BCCS-9202
2	**Title of the subject**	High Speed Networks/Internet Traffic- Measurement, Modelling and Analysis
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr Sunil Kumar
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ After successful completion of this course, students will able to learn High speed networks, traffic and congestion management system. Study of wireless network operations, resource allocation, service management
8	**Brief Contents (module wise)**	Module-I Introduction to high speed networks (HSNs): frame relay networks, ATM protocols, architecture and logical connections, high speed LAN, Ethernet-fiber and wireless-LANS. Module-II Congestion and Traffic Management: Congestion and flow error control, TCP traffic congestion control in ATM networks, Performance of TCP over ATM. Module-III QOS in IP Networks: Integrated service architecture- queuing discipline, Multicast Transport Protocol (MTP), Resource Reservation Protocol (RSVP), Real-Time Transport Protocol (RTP), QoS Architectures, QoS Support for Multicast. Module-IV Wireless network and its operations: Local broad band and Ad hoc networks, wireless LANS-IEEE802.11 WLAN-WATM- HIPERLAN-Ad hoc networking and WPAN. Module-V Network management, configuration selection method- MIB-SNMP-XMLCORBA-COPS-VPNS-mobile IP-voice over IP. Ni
9	**Contents for lab (If applicable)**	NO
10	**List of text books/references**	1. William Stallings, High Speed Network and Internet, Pearson Education, Second Edition,2002. 2. Warland and Pravin Varaiya, High Performance Communication Networks, Jean Hardcourt Asia Pvt. Ltd., II Edition, 2001 3. Williams Stallings, ”High Speed networks And Internet Performance And Quality Of Service”, Pearson Second Edition,2002.

1	**Code of the subject**	BCCS-9203
2	**Title of the subject**	Cellular and Mobile Communication Systems
3	**Any prerequisite**	Computer Networks
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Prasenjit Chanak
6	**Will this course require visiting faculty**	NA
7	**Learning Objectives of the subject (in about 50 words)**	After completion of the course student will be able to: • Understand the evolution of cellular communication systems upto and beyond 3G. • Design a cellular link and estimate the power budget. • Choose proper multiple accessing methods depending on channel model. • Identify traffic channels for call processing. • Calculate key performance metrics of a cellular communication system.
8	**Brief Contents (module wise)**	• Introduction to mobile communication: Introduction - Everything moves - Mobility versus portability - Mobile devices – Wireless communication and the layer model - First- and Second- Generation Cellular Systems - Cellular Communications from 1G to 3G - Road Map for Higher Data Rate Capability in 3G - Wireless 4G Systems - Future Wireless Networks – Standardization Activities for Cellular Systems. • Cellular System design concepts and fundamentals: Frequency Reuse- Channel Assignment - Handoff Strategies-Interference and System Capacity -Trunking and Grade of service-Improving Coverage and Capacity in cellular systems. Mobile Radio Wave propagation - I - Large scale path loss and propagation models – Reflection-Diffraction –Scattering-Practical link budget design-Outdoor propagation models-Indoor propagation models. • Mobile Radio Wave propagation-II-Small-Scale fading and multipath propagation, Rayleigh & Ricean Distributions. Multiple Access Techniques for Wireless Communications-I-FDMA-TDMA-Spread Spectrum multiple access-FHMA, CDMA-SDMA. • Multiple Access Techniques for Wireless Communications-II -Packet radio -Pure ALOHA, Slotted ALOHA, CSMA, Reservation ALOHA, PRMA - Capacity of Cellular Systems. Wireless systems & standards- I - AMPS & ETACS-IS 54 & IS 136-GSM features-Architecture–Radio subsystems -Traffic channels-call processing. • Wireless systems and standards – II –CDMA features –Architecture –IS 95 – Forward and reverse channels –power constrol - system capacity. Wireless Networking – WLAN-PAN – Mobile network layer-Mobile Transport layer – Wireless data services, Common channel signalling. • Wireless Networking-Satellite data communication-cellular data communications, third generation UMTS system features -WiMAX - RFID.
9	**Contents for lab**	NA
10	**List of text books/references**	• W. C Y Lee, Mobile Cellular Telecommunications, McGraw Hill. • Stallings, Wireless Communications and Networks, Prentice Hall. • Schwartz, Mobile Wireless Communications, Cambridge Univ.Press. • T. S Rappaport,Wireless Communications Principles and Practice, Prentice Hall.

1	**Code of the subject**	BCCS-9204
2	**Title of the subject**	Wireless Sensor Networks
3	**Any prerequisite**	Computer Networks
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. W. Wilfred Godfrey
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject**	To provide a comprehensive knowledge about wireless sensor networks with insights into different layers, their design considerations and infrastructure establishment details.
8	**Brief Contents (module wise)**	**Module 1-Characteristics of WSN:** Characteristic requirements for WSN - Challenges for WSNs-WSN vsAdhoc Networks -Sensor node architecture - Commercially available sensor nodes-Imote, IRIS, Mica Mote, EYES nodes, BTnodes, TelosB, Sunspot-Physical layer and transceiver design considerations in WSNs, Energy usage profile, Choice of modulation scheme, Dynamic modulation scaling, Antenna considerations. **Module 2- Medium Access Control Protocols:** Fundamentals of MAC protocols -Low duty cycle protocols and wakeup concepts -Contention-based protocols-Schedule-based protocols -SMAC-BMAC-Traffic-adaptive medium access protocol (TRAMA) -The IEEE 802.15.4 MAC protocol. **Module 3 - Routing And Data Gathering Protocols:** Routing Challenges and Design Issues in Wireless Sensor Networks, Flooding & gossiping-Data centric Routing-SPIN-Directed Diffusion-Energy aware routing -Gradient-based routing-Rumor Routing-COUGAR-ACQUIRE-Hierarchical Routing -LEACH, PEGASIS-Location Based Routing-GF, GAF, GEAR, GPSR-Real Time routing Protocols-TEEN, APTEEN, SPEED, RAP-Data aggregation-data aggregation operations-Aggregate Queries in Sensor Networks -Aggregation Techniques-TAG, Tiny DB. **Module 4-Embedded Operating Systems:** Operating Systems for Wireless Sensor Networks-Introduction-Operating System Design-Ex.of OS-TinyOS-Mate-MagnetOS -MANTIS-OSPM-EYES OS-SenOS-EMERALDS-PicOS-Int. to Tiny OS-NesC-Interfaces & Modules-Configurations &Wiring-Generic Components-Prog.in Tiny OS using NesC, Emulator TOSSIM. **Module 5-Applications of WSN:** WSN Applications-Home Control-Building Automation-Industrial Automation-Medical App.-Reconfigurable Sensor Networks-Highway Monitoring-Military Applications-Civil& Environmental Engg. Applications-Wildfire Instrumentation -Habitat Monitoring-Nanoscopic Sensor Appl.-Case Study: IEEE 802.15.4 LR-WPANs Standard-Target detection& tracking-Contour/edge detection-Field sampling.
9	**Contents for lab**	NIL
10	**List of text books/references**	1.K. Sohraby, D. Minoli & T. Znati, Wireless Sensor Networks Technology, Protocols and Applications, John Wiley & Sons, 2007. 2.H. Karl &A. Willig ,Protocols& Architectures for Wireless Sensor Networks, John Wiley & Sons, Ltd, 2005. 3.K. Akkaya & M. Younis, A survey of routing protocols in wireless sensor networks, Elsevier Ad Hoc Network Journal, Vol. 3, pp. 325-349 . 4.. Levis, Tiny, OS Programming"3.Anna Ha´c, Wireless Sensor Network Designs, John Wiley & Sons Ltd.

1	**Code of the subject**	BCCS-9205
2	**Title of the subject**	Special Topics in Complex Networks
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Prasenjit Chanak
6	**Will this course require visiting faculty**	NA
7	**Learning Objectives of the subject (in about 50 words)**	The objective of this course is to acquaint participants with some of fundamental concepts and state-of-the-art research in the areas of complex networks &network science. This is a research oriented course with wide applications in fields of social network, data science, information retrieval, communication system and economics and finance. The major focus of course is to study of models and behaviors of networked systems. Empirical studies of social, technological, information and financial networks. Exploring the concepts of small world effect, degree distribution, clustering, network correlations, random graphs, models of network growth &preferential attachment and dynamical processes taking place on networks. It is implicitly expected that the registrants have already gone through basic courses on mathematics.
8	**Brief Contents (module wise)**	**Introduction:** Overview of Network science, Motivation, Large scale dynamic networks, Challenges of graph theory **Basic Concepts related to Networks:** Small world effect,transitivity& clustering, degree distribution, scale free networks, max. degree; network resilience; mixing patterns; degree correlations; community structures **Community Structure Analysis:** Basic concepts of network communities, Modularity,various community finding approaches Girvan-Newman Algorithm, Spectral Bisection Algorithm, Radicchi Edge Clustering Algorithm,Wu-Hubermann Algorithm, Random Walk Algorithm, Louvain **Random Graphs:** Poisson random graphs, generalized random graphs, configuration model, generating functions, power-law degree distribution, directed graph, bipartite graph, degree correlations **Models of Network Growth:** Price model, Barabasi& Albert model, other growth models, vertex copying models, Bipartite Network **Processes taking place on Networks:** Percolation theory and network resilience, Epidemiological processes, Cascades and information spread **Social Network:** Homophily, Cohesiveness, Cliques, Clans, Clubs, Plex, Equivalence of ties, Ego-centric networks, Cascade formation and information diffusion in Social media (say Twitter). **Applications:** Search on networks, exhaustive network search, guided network search, network navigation; network visualization & semantic zooming. **Advanced topics:** Temporal network, Multilayer networks, Interdependent networks, Controllability of complex networks, Economic & financial network
9	**Contents for lab**	NA
10	**List of text books/references**	1.Networks: An Introduction, Oxford University Press, Oxford, 2010. 2.Evolution of Networks, Oxford Univ. Press, Oxford, 2003. 3.The structure & function of complex networks, SIAM Review 45,2003. 4. Statistical mechanics of complex networks, Rev. Mod. Phys., 74(1), 2002. 5. Papers from the ACM and IEEE digital libraries.

1	**Code of the subject**	BCCS-9206
2	**Title of the subject**	Parallel and Distributed Computing
3	**Any prerequisite**	Advanced Computer Architecture, Distributed Operating System
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Neetesh Kumar
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	The course is intended to provide basic foundation with fundamental concepts and mechanisms of parallel and distributed computing systems. Most of the issues discussed in this course material are the essence of Advance computer architectures and advanced operating systems.
8	**Brief Contents (module wise)**	**Module I:** Introduction to Parallel Processing: Evolution of Computer System, Parallelism in Uni-Processor, Parallel Computer Structures. **Module II:** Architectural Classification Schemes, Multiprocessor Architectures Parallel Computing System Architectures **Module III:** Principles of Pipelining and principals, Pipeline Computers, Introduction to parallel Programming **Module IV:** Basic Concepts of Distributed Systems: Computer architecture : CICS, RISC, Multi-core Computer networking : ISO/OSI Model Evolution of operating systems Introduction to distributed computing systems (DCS) **Module V:** Distributed Coordination: Temporal ordering of events Lamport's logical clocks Vector clocks; Ordering of messages Physical clocks Global state detection, Distributed mutual exclusion algorithms Performance matrix. **Module VI:** Inter-process communication: Message passing communication Remote procedure call Transaction communication Group communication; Broadcast atomic protocols. **Module VII:** Deadlocks in distributed systems **Module VIII:** Load scheduling and balancing techniques
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	1. Distributed Systems Concepts and Design, G. Coulouris, J. Dollimore, Addison Wesley 2. Advanced Operating Systems, M. Singhal, N.G. Shivarathri, McGraw Hill 3. Distributed Operating Systems and Algorithms, Randy Chow, T. Johnson, Addison Wesley 4. Distributed Operating Systems, A.S. Tanenbaum, Prentice Hall 5. Principles of Distributed Database Systems, M. Tamer Ozsu, Patrick Valduriez, Prentice Hall International 6. Computer Architecture & P arallel P rocessing, Kai Hawang, McGraw-Hill.

1	**Code of the subject**	BCCS-9207
2	**Title of the subject**	Grid & Peer to Peer Computing
3	**Any prerequisite**	Operating Systems, Networks
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Ritu Tiwari
6	**Will this course require visiting faculty**	
7	**Learning Objectives of the subject (in about 50 words)**	This course is an advanced elective and covers material relating to distributed computing fundamentals, grid computing middleware, and high performance applications. The pre-requisites for the course are operating systems, networks. A prior course on distributed systems is an added advantage.
8	**Brief Contents (module wise)**	**GridComputing**: Introduction to Grid Computing, Classification of Grids, Introduction toService Oriented Computing **Peer-to-Peer (P2P) Concepts in Grids**: Introduction to systems, Overlays Unstructured P2P systemsT(Gnutella, Freenet), Structured P2P systems (Distributed Hash Tables - Chord,Tastry), Integrating unstructuredTandTstructured P2PTsystems, Introduction to P2P security – Sybil attacks **GridComputingMiddleware**:Functions/Challenges of a Gridcomputing middleware, Globus: Open source software toolkit used for building Grid systemsand applications , Vishwa: A reconfigurable P2P middleware for Grid computations **GridSecurity and Resource Management**: Grid Security-A Brief Security Primer-PKI-X509, Certificates-Grid Security-Grid Scheduling and Resource Management-SchedulingT aradigms- Working principles of Scheduling -A Review of Condor, SGE,TPBS and LSF-Grid Scheduling with QoS **Current p2p systems**: Napster, Gnutella, KazaA, FreeNet, Pastry, Tapestry.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	**Text Books:** 1. D. Janakiram, Grid Computing, Tata Mcgrahill 2. Maozhen Li, Mark Baker, The Grid Core Technologies, John Wiley & Sons **References:** 1. Ian Foster & Carl Kesselman,The Grid 2Blueprint for a New Computing Infrascture Morgan Kaufman 2. Joshy Joseph & Craig Fellenstein, Grid Computing Pearson Education. 3. Fran Berman, Geoffrey Fox, Anthony J.G.Hey, Grid Computing: Making the Global Infrastructure a reality John Wiley and sons, 4. AbdelkaderHameurlain&A. Min Tjoa, Data Managementin Grid and peer to peer systems, Springer 5. Anirban Chakraborty, Grid Computing Security, Springer

1	**Code of the subject**	BCCS-9208
2	**Title of the subject**	Special Topics in Internet Technologies
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Pinku Ranjan
6	**Will this course require visiting faculty**	**NO**
7	**Learning Objectives of the subject (in about 50 words)**	➢ Students will understand the concepts of Internet. ➢ The evolution object oriented programming languages ➢ Application of object oriented programming to solve business and enterprise problems 3. The basic syntax of Java language ➢ The concepts of object oriented programming ➢ Install the programming environment for programming in Java ➢ Write programs encapsulating simple logic ➢ Compile, debug, and run Java programs ➢ Able to create simple classes
8	**Brief Contents (module wise)**	➢ ***Introduction to Web Design*** :Introduction to hypertext markup language (html) document type definition, creating web pages, graphical elements, lists, hyperlinks, tables, web forms, inserting images, frames. ➢ ***Customized Features:*** Cascading style sheets, (css) for text formatting and other manipulations. ➢ ***JavaScript:*** Data types, operators, functions, control structures, events and event handling. ➢ ***Java:*** Use of Objects, Array and Array List class, Designing classes, Inheritance, Input/Output, Exception Handling. ➢ ***JDBC:***JDBC Fundamentals, Establishing Connectivity and working with connection interface,Working with statements, Creating and Executing SQL Statements, Working with Result Set Objects. ➢ ***JSP:*** Introduction to JavaServer Pages, HTTP and Servlet Basics, The Problem with Servlets, The Anatomy of a JSP Page, JSP Processing, JSP Application Design with MVC, Setting Up the JSP Environment, Implicit JSP Objects, Conditional Processing, Displaying Values ➢ Using an expression to set an Attribute, Declaring Variables and Methods, Error Handling and Debugging, Sharing Data Between JSP Pages, Requests, and Users, Database Access.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1.Web Enabled Commercial Application Development Using Html, Dhtml, javascript, Perl Cgi By Ivan Bayross, BPB Publications, 2009. 2. BIG Java Cay Horstmann, Wiley Publication , 3rd Edition., 2009 3. Java 7 ,The Complete Reference, Herbert Schildt, 8th Edition, 2009. 4. The Complete Reference J2EE, TMH, Jim Keogh, 2002. 5. Java Server Pages, Hans Bergsten, Third Edition, O'Reilly Media December 2003.

1	**Code of the subject**	BCCS-9209
2	**Title of the subject**	Next Generation Networks
3	**Any prerequisite**	Cellular and Mobile Communication Systems
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Vinal Patel
6	**Will this course require visiting faculty**	NA
7	**Learning Objectives of the subject (in about 50 words)**	➢ A working knowledge of emerging network technologies, how they are used, what their advantages or disadvantages. ➢ Summarize architecture and technology options for Multi-Service Networks. ➢ Identify the key technologies for core, access and infrastructure.
8	**Brief Contents (module wise)**	**Module I:**Introduction to next generation networks: Communicating in the new Era, New Era of Networking, Technologies influencing change, IP Everywhere, Optical fiber anywhere, wireless access, building blocks for NGN, IP Networks, VOIP, Multi service Flexible Networks architecture. VPNs, Optical Networks, Wire line and Wireless Networks, NGN Services, Network Infrastructure convergence, services convergence, from technology push to service pull. **Module II:**IP Networks: IP past, present and future, IP influence and confluence, IP version 4, I. P. Version 6, IP Network convergence, LAN Technologies, IP Routing, LAN Switching, WAN's, WAN Technologies and Topologies. Wireless IP LANS, Mobility Networks, Global IP Networks, Global capacity, Globally Resilient IP, Internet -A Network of Networks. Beyond IP, Technology Brief - IP Networks, Business Drivers, Success factors, Applications and Service Value. **Module III:** Multi service Networks: Origin of multi service ATM, Next Generation Multi service Networks, Next Generation Multi service ATM switching, Multi-protocol Label switching, Networks, Frame Based MPLS, Cell based MPLS, MPLS services and their benefits, multi service provisioning platforms (MSPP) and Multi service switching platform (MSSP). **Module IV:** NGN Applications: Internet connectivity, e-commerce, call center, third party application service provision, UMTS, WAP, WiMAX, integrated billing, security and directory enable networks.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1.Next Generation Network Services: Technologies and Strategies, Neill Wilkinson, Wiley,2002. 2. Next Generation Network Services, Robet Wood, Pearson, 2005.

1	**Code of the subject**	BCCS-9210
2	**Title of the subject**	Cognitive Network
3	**Any prerequisite**	Digital Communication
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Vinal Patel
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ The Students will be enabled to understand and acquire knowledge in cognitive networks. ➢ To emphasis on knowledge-building to understand architectures for various networks. ➢ To provide a complete understanding on concepts, to identify the pros and cons of designing a cognitive network and SDR.
8	**Brief Contents (module wise)**	**Module I:** Aware, Adaptive and cognitive networks, Cognitive network technology, cognitive network Architectures, cognitive radio Networks Applications. **Module II:** Network Coding for Cognitive Relay Networks. Cognitive Networks Architecture. Terminal Architecture for CN. Mathematical Models Toward Networking Cognitive Radios. Scaling Laws of CN. **Module III:** Spectrum Sensing to detect specific Primary System. Spectrum Sensing for cognitive Radio OFDMA Systems and cognitive multi-network system. Spectrum Management- Spectrum Sharing, Spectrum Pricing, Mobility Management to Heterogeneous Wireless Networks, Regulatory Issues and International Standards. **Module IV:** Framework of Trust in CRN; Trusted Association and Routing; Trust with Learning; Security in CRN. Introduction to SDR. Evolution of SDR Baseband Requirements. SDR Architectures -Ideal SDR Architectures, Realistic SDR Architecture. SDR and Cognitive Radio Relationship.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks”, John Wiley & sons, 2009. 2. Ahmed Khattab, Dmitri Perkins, MagdyBayoumi, “Cognitive Radio Networks: From Theory to Practice”, Springer, 2013.

1	**Code of the subject**	BCCS-9211
2	**Title of the subject**	Information Theory and Coding
3	**Any prerequisite**	Students should have brief idea about linear algebra.
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Aditya Trivedi
6	**Will this course require visiting faculty**	NO.
7	**Learning Objectives of the subject (in about 50 words)**	This course gives brief knowledge about the basic algebraic relationships of entropy, relative entropy, and mutual information. In this course students are going to learn how to compress the data using source coding and how to make data transmission reliable using channel coding. It introduces the basic principles of encoding, decoding, error detecting and error correcting techniques.
8	**Brief Contents (module wise)**	**1. Information Theory** Introduction, Discrete memory less source, Binary source. **2. Entropy, Relative Entropy, and Mutual Information** Entropy, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information, Relationship Between Entropy and Mutual Information, Chain Rules for Entropy, Relative Entropy, and Mutual Information, Jensen's Inequality, Log Sum Inequality. **3. Data Compression** Examples of Codes, Kraft Inequality, Optimal Codes, Bounds on the Optimal Code Length, Kraft Inequality for Uniquely Decodable Codes, Huffman Codes, Shannon–Fano Coding. **4. Channel capacity** Examples of Channel Capacity, Symmetric Channel, Channel Coding Theorem. **5. Error detecting and Error correcting code** Simple parity checks , CRC codes, Hamming weight , Hamming distance, Minimum distance decoding, Single/Double parity checks, Hamming codes, Linear block codes, Cyclic codes, Syndrome calculation, Block encoders and Decoders.
9	**Contents for lab (If applicable)**	
10	**List of text books/references**	1. Elements of Information Theory by Joy A. Thomas and Thomas M. Cover, John Wiley and Sons. 2. Digital Communication by John G.Proakias, McGraw Hill, Singapore, 4 th Edition, 2001. 3. Digital Communications: Fundamentals and Applications, 2nd Ed., Bernard Sklar, Pearson Prentice Hall, 2001.

1	**Code of the subject**	BCCS-9212
2	**Title of the subject**	Detection and Estimation Theory
3	**Any prerequisite**	Student must have basic knowledge about linear algebra, probability and random process.
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Aditya Trivedi
6	**Will this course require visiting faculty**	NO.
7	**Learning Objectives of the subject (in about 50 words)**	Detection theory involves detecting one hypothesis from two or more than two hypotheses. This may be done based on Bayes detection, Minmax detection, NP test. Estimation theory is a branch of statistics that deals with estimating the values of parameters based on measured empirical data that has a random component using various estimators. In general, the information that one wishes to extract from such observation is unknown to the observer, it is useful to cast detection and estimation problems in a probabilistic framework in which unknown behavior is assumed to be random. Applications of the theory of signal detection and estimation are in many areas, such as communications, automatic control, telecommunication, radar etc.
8	**Brief Contents (module wise)**	**1.Background:** Review of Gaussian variables and processes. **2.Statistical Decision Theory:** Bayesian, minimax, and Neyman-Pearson decision rules, likelihood ratio, composite hypothesis testing. **3.Detection of Deterministic Signals:** Matched filter detector and its performance. **4.Detection of Random Signals:** Estimator-correlator, linear model, general Gaussian detection. **5.Nonparametric Detection:** Detection in the absence of complete statistical description of observations. **6.Estimation of Signal Parameters**: Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, sufficient statistics. **7. Signal Estimation in Discrete-Time:** Linear Bayesian estimation, Weiner filtering, dynamical signal model, discrete Kalman filtering.
9	**Contents for lab (If applicable)**	
10	**List of text books/references**	1. H. L. Van Trees, "Detection, Estimation and Modulation Theory, John Wiley and sons 2004.. 2. Signal detection and estimation by *MouradBarkat, Artech House 1991.* 3. AN INTRODUCTION TO SIGNAL DETECTION AND ESTIMATION BY POOR**,**H. VINCENT, SPRINGER 1998.

Electives (Security)

1	**Code of the subject**	BCCS-9301
2	**Title of the subject**	Computer Security Audit and Assurance
3	**Any prerequisite**	Information Security
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Debanjan Sadhya
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• Provide management with an assessment of an organization's cyber security policies, procedures and their operating effectiveness. • Identify internal control and regulatory deficiencies that could put the organization at risk.
8	**Brief Contents (module wise)**	**Module I**: Security Policy frameworks: practices, and procedures, business practice disclosures. **Module II**: Policy authority and practices, information security practices, personal and physical security practices, operation management practices. **Module III**: PKIs and key management schemes, key generation, key storage, backup, recovery and distribution. **Module IV**: XML frameworks for security policy specification, certificate management life cycle. **Module V**: Auditing for security:Basic terms related to audits, security audits, need for security audits, auditor's responsibility in security audits, types of security audits. **Module VI**: Approaches to audits, technology based audits vulnerability scanning and penetration testing, resistance to security audits, phases in security audits, engagement costs, budgeting, and key success factors for security audits.
9	**Contents for lab (If applicable)**	N/A
10	**List of text books/references**	1."Information Security And Audit", Sunil Khilari, Ramesh Jadhav, Abiresh Abrahem,*Everest Publishing House*. 2."Information Security Management Handbook", Harold F. Tipton, Micki Krause, *CRC Press*. 3. "Security Risk Management: Building an Information Security Risk Management Program from the Ground Up", Evan Wheeler, *Syngress*.

1	**Code of the subject**	BCCS-9302
2	**Title of the subject**	Cryptography and Network Security
3	**Any prerequisite**	NIL
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Anuraj Singh
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ 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
8	**Brief Contents (module wise)**	**Module I- Introduction** Classical Encryption Techniques: Symmetric Cipher Model, Substitution Techniques, Transposition Techniques, Stream Cipher and Block Cipher, Random Number Generator, One-time Pad. **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. **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. **Module IV-Cryptographic Protocols** Authentication Requirement, Authentication Function, MAC, Hash Functions, Security of Hash Function , Digital Signatures, **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
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	1. William Stallings, Cryptography and Network security, 4e,Prentice Hall of India, New Jersey, 2008. 2. ChristofPaar, 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**	BCCS-9303
2	**Title of the subject**	Computer Systems Security
3	**Any prerequisite**	Operating Systems Concepts, Computer Networks, Information System Security
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Saumya Bhadauria
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• This course provides an advanced comprehensive study of the security principles and practices of operating and database systems.
8	**Brief Contents (module wise)**	Module I: Software Security, Software Security Issues, Handling Program Input, Interacting with the Operating System and Other Programs Module II: Operating System Security: Introduction, security system planning, security maintenance Module III: Access Control Fundamentals, Multics, Security models, Security Kernels
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	• William Stallings and Lawrie Brown. 2014. *Computer Security: Principles and Practice* (3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA. • Trent Jaeger. 2008. Operating System Security (1st ed.). Morgan and Claypool Publishers.

1	**Code of the subject**	BCCS-9304
2	**Title of the subject**	Web Architecture Security
3	**Any prerequisite**	Information Security
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Debanjan Sadhya
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• Get an overview of web applications, its history, benefits, drawbacks, and future. • Look at the emerging Web services architecture and take a first pass at identifying some of the major soft spots. • Be aware of the vulnerabilities of web applications. • Get a clear understanding of the flaws, myths and best practices for WAS.
8	**Brief Contents (module wise)**	**Module I**: Introduction to Web services architecture, Service oriented architecture and distributed systems. **Module II**: The architectural models: policy model, service oriented model, resource oriented model, message oriented model. **Module III**: Web Applications and IT Infrastructure essentials: how a web application works (http, cookies, session affinity etc.), middleware components part of the application chain, TCP/IP transport protocol and the BGP protocol, the HTTP protocol and session management. **Module IV**: Security controls offered by SSL/TLS and identify the steps for a successful SSL/TLS handshake, symmetric and asymmetric encryption, understand why certificate management is vital. **Module V**: High availability, Operational management and application chains: Understand the different levels of high availability, latency, Recovery Time Objective (RTO) and Recovery Point Objective (RPO), horizontal and vertical scaling.
9	**Contents for lab (If applicable)**	N/A
10	**List of text books/references**	1."Designing Security Architecture Solutions", Jay Ramachandran,*Wiley*. 2. "Web Application Security, A Beginner's Guide" Bryan Sullivan, Vincent Liu, *McGraw Hill*. 3.Web Services Architecture and Security (https://www.owasp.org/index.php/Web_Services_Architecture_and_Security).

1	**Code of the subject**	BCCS-9305
2	**Title of the subject**	Cyber Security and Laws
3	**Any prerequisite**	No
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Pinku Ranjan
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject**	➢ realize the activities carried using forensic technologies in detection of cyber crime ➢ introduce a novel methodology of performing cyber forensics or system forensics ➢ relate the laws enforced by the judiciary to handle cybercrimes and cyber frauds ➢ assess how the digital evidences will be handled in any crime scene
8	**Brief Contents (module wise)**	***Computer and Cyber Forensic Basics***: Introduction to Computers, Computer History, Software, Hardware, Classification, Computer Input-Output Devices, Windows, DOS Prompt Commands, Basic Computer Terminology, Internet, Networking, Computer Storage, Cell Phone / Mobile Forensics, Computer Ethics and Application Programs, Cyber Forensic Basics-Introduction to Cyber Forensics, Storage Fundamentals, File System Concepts, Data Recovery, Operating System Software and Basic Terminology ***Data and Evidence Recovery:*** Introduction to Deleted File Recovery, Formatted Partition Recovery, Data Recovery Tools, Data Recovery Procedures and Ethics, Preserve and safely handle original media, Document a "Chain of Custody", Complete time line analysis of computer files based on file creation, file modification and file access, Recover Internet Usage Data, Recover Swap Files/Temporary Files/Cache Files, Introduction to Encase Forensic Edition, Forensic Tool Kit (FTK), Use computer forensics software tools to cross validate findings in computer evidence-related cases. ***Cyber Crimes and Cyber Laws:*** Introduction to IT laws & Cyber Crimes – Internet, Hacking, Cracking, Viruses, Virus Attacks, Pornography, Software Piracy, Intellectual property, Legal System of Information Technology, Social Engineering, Mail Bombs, Bug Exploits, and Cyber Security ***Cyber Forensics Investigation:*** Introduction to Cyber Forensic Investigation, Investigation Tools, eDiscovery, Digital Evidence Collection, Evidence Preservation, E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Encryption and Decryption methods, Search and Seizure of Computers, Recovering deleted evidences, Password Cracking ***Cyber Security:*** Introduction to Cyber Security, Implementing Hardware Based Security, Software Based Firewalls, Security Standards, Assessing Threat Levels, Forming an Incident Response Team, Reporting Cyber crime, Operating System Attacks, Application Attacks, Reverse Engineering & Cracking Techniques and Financial Frauds ***Security Audit and Standards:*** Risk Assessment and Management, Asset Classification, Crisis Management Plan, Resources Recovery Strategy, Security Testing, International Standards, Analysis and Logging, Security Certification
9	**Contents for lab**	NO
10	**List of text books/references**	1.Raghu Santanam, Sethumadhavan, MohitVirendra, Cyber Security, Cyber Crime and Cyber Forensics: Applications and Perspectives, IGI Global 2. Chris Davis, IT Auditing Using controls to protect Information Assets,TMH

1	**Code of the subject**	BCCS-9306
2	**Title of the subject**	Malware Analysis
3	**Any prerequisite**	Computer Organization,Computer Architecture, Networks, and Operating Systems, and memory layout of programs; be able to understand x86 and other assembly; a general understanding of computer security.
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Shashikala Tapaswi
6	**Will this course require visiting faculty**	As expert lectures
7	**Learning Objectives of the subject (in about 50 words)**	The increasingly networked nature of the modern world has also enabled the spread of malicious software, or "malware", ranging from annoying adware to advanced nation-state sponsored cyber-weaponry. As a result, the ability to detect, analyze, unders tand, control, and eradicate malware is an increasingly important issue of economic and national s ecurity. This course will introduce students to modern malware analysis techniques through readings and h ands-on interactive analysis of real-world samples. After successful completion of this course students will be equipped with the skills to analyze advanced contemporary malware using both static and dynamic analysis. Focus on executable binaries, object file formats, and the use of tools such as debuggers, virtual machines, and disassemblers. Obfuscation and packing schemes will be discussed, along with various issues related to Windows internals.
8	**Brief Contents (module wise)**	Introduction to malware, Basic Static and Dynamic Analysis, Overview of Windows file format, PEView.exe, Patching Binaries , Disassembly(objdump, IDA Pro), Introduction to IDA, Introduction to Reverse Engineering, Extended Reverse Engineering using GDB and IDA, Advanced Dynamic Analysis - debugging tools and concepts, Malware Behavior - malicious activities and techniques, Knowledge of relevant system internals, and experience in using various malware analysis tools Analyzing Windows programs – WinAPI, Handles ,Networking , COM, Data Encoding, Malware Countermeasures , Covert Launching and Execution, Anti Analysis - Anti Disassembly, VM, Debugging -, Packers – packing and upacking, Intro to Kernel – Kernel basics, Windows Kernel API, Windows Drivers, Kernel Debugging, Rootkit Techniques- Hooking, Patching, Kernel Object Manipulation , Rootkit Anti-forensics , Covert analysis.
9	**Contents for lab (If applicable)**	"Hands on" students may bring their laptops to class session.
10	**List of text books/references**	**References:** 1. "Practical Malware Analysis" by Michael Sikorski and Andrew Honig, ISBN: 1593272901, No Starch Press,2012 2. "The Rootkit Arsenal: Escape and Evasion in the Dark Corners of the System" , Second Edition by Reverend Bill Blunden 3. "Rootkits: Subverting the Windows Kernel" by Jamie Butler and Greg Hoglund, ISBN: 0321294319, 4. "Practical Reverse Engineering" by Dang, Gazet, Bachaalany , Wiley,2014 5. "The IDA PRO Book: The Unofficial Guide to the World's Most Popular Disassembler, 2nd Edition" by Chris Eagle (published by No Starch Press, 2011)

1	**Code of the subject**	BCCS-9307
2	**Title of the subject**	IoT and its Security
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Prasenjit Chanak
6	**Will this course require visiting faculty**	NA
7	**Learning Objectives of the subject (in about 50 words)**	The objective of this course is to acquaint participants with some of the fundamental concepts and state-of-the-art research in the areas of IoT and its Security. This is a research oriented course. This course has no official prerequisites. However, it is implicitly expected that the registrants have already gone through the basic courses on mathematics. The outline of the course is given below

8	**Brief Contents (module wise)**	**The course will be broad in nature and will include the following topics:**
		• IoT definitions: overview, applications, potential & challenges
		• Competitive Landscape
		• IoT examples: Case studies
		  ○ Sensor body-area- network
		  ○ Control of a smart home
		  ○ Smart Vehicles
		  ○ Smart Manufacturing & Smart Factory
		• Architecture
		• Protocols
		• Performance Modeling & Analysis
		• Industrial IoT (IIoT) and the Industrial Internet Consortium (IIC)
		• Introduction to IoT Security
		• Emerging IoT Standards
		• Open Problems & Research challenges

9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1.The Fourth Industrial Revolution by Klaus Schwab 2. Learning Internet of Things by Peter Waher 3. Papers from the ACM and IEEE digital libraries.

1	**Code of the subject**	BCCS-9308
2	**Title of the subject**	Formal methods for Security
3	**Any prerequisite**	Discrete Mathematics, Compilers, Operating Systems Concepts, Information System Security
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. SaumyaBhadauria
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	To make use of mathematical background to understand and use formal methods like set theory, propositional logic and operational semantics
8	Brief Contents (module wise)	Module I: Formal Specifications and Models: Introduction to Formal Methods, Mathematical Background , Formal Specifications and Formal Models, Case Study Formal Specifications and Models Module II: Model Checking and Formal Verification : Model checking, Advanced models: Real-time models , Case Study Formal Verification Module III: Static and Dynamic Analysis of programs
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	• Handbook of System Safety and Security by Edward Griffor, 2016 • Formal Modeling and Verification of Cyber-Physical Systems by Rolf Drechsler, Ulrich Kühne, 2015.

1	**Code of the subject**	BCCS-9309
2	**Title of the subject**	Modern Cryptology
3	**Any prerequisite**	-
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Jeevaraj S
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ To make the students understand the process of deciphering coded messages without being told the key. ➢ To study of codes and the art of writing and solving them. ➢ To give motivation towards recent research development in the field of cryptography, cryptanalysis, and steganography. ➢ Overall this course explores modern cryptographic (code making) and cryptanalytic (code breaking) techniques in detail.
8	**Brief Contents (module wise)**	Number Theory Basics Modular arithmetic Fields, Binary Fields Primes, GCD and Chinese reminder 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.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	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**	BCCS-9310
2	**Title of the subject**	Specialized Couse in Cryptography
3	**Any prerequisite**	NIL
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Anuraj Singh
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ To develop a framework to understand advanced cryptographic aspects. ➢ To enhance an ability to analyze a problem, and identify and define the computing requirements for data security. ➢ To provide a logical and rational background to develop a dynamics cryptographic algorithm.
8	**Brief Contents (module wise)**	**Module I-** Steganography, Security Attacks Shift Register-Based Stream Ciphers, Linear Feedback Shift Registers, Known-Plaintext Attack Against Single LFSRs, Trivium. **Module II-**DESX, Lightweight Cipher PRESENT, Block Cipher Modes of Operation: ECB, CBC, OFB, CFB, CTR, GCM CAST, GOST, Blowfish, RC5 Algorithm. **Module III-**Diffie Hellman Key Exchange, Elgamal Encryption, Knapsack Algorithm, Rabin Algorithm, McEliece, LUC. **Module IV-**Authentication Protocols, SHA, MD5, SHA-1, Key Negotiation, PKI Reality. **Module V-**Key Establishment: Key Freshness and Key , The n^2 Key Distribution ProblemKey establishment using Symmetric Techniques, Key establishment using Asymmetric Techniques, Certificates
9	**Contents for lab (If applicable)**	NIL
10	List of text books/references	1. ChristofPaar, Jan Pelzl, Understanding Cryptography, Springer-Verlang, Berlin, 2010. 2. Behrouz A Forouzan, Cryptography and Network security, Tata Mc-Graw Hill, New York, 2007. 3. Bruce Schneier, Applied Cryptography: Protocols, Algorithms and Source Code in C, John Wiley & Sons, Indianapolis 2015. 4. Niels Ferguson, Bruce Schneier, Tadayoshi Kohno, Cryptography Engineering: Design Principles and Practical Applications, John Wiley & Sons, Indianapolis, 2010.

1	**Code of the subject**	BCCS-9311
2	**Title of the subject**	Information Security and Secure Coding
3	**Any prerequisite**	Information security
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Debanjan Sadhya
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• Learn how secure coding is important when it comes to lowering risk and vulnerabilities. • Identify the insecure coding practices that lead to common software programming errors. • Learn about XSS, Direct Object Reference, Data Exposure, Buffer Overflows, Resource Management, Active Defences, and Threat Modelling.
8	**Brief Contents (module wise)**	**Module I**: Introduction, Injections (SQL, command, JSON), defenses, Broken authentication and Session management. **Module II**: Cross-site Scripting (reflected XSS HTML, reflected XSS JS), Insecure direct object reference, Security misconfiguration. **Module III**: Sensitive data exposure, Missing function level access control, Cross-site request forgery. **Module IV**: Using components with known vulnerabilities, Invalidated redirects and forwards. **Module V**: Buffer overflows, Insecure interaction between components. **Module VI**: Risky resource management, Porous defenses, Active defenses, Threat modeling.
9	**Contents for lab (If applicable)**	N/A
10	**List of text books/references**	1."Fundamentals of Cyber Security", MayankBhushan, Rajkumar Singh Rathore, AatifJamshed, *BPB Publications*. 2. "Building Secure Software: How to Avoid Security Problems the Right Way", Viega, John, Gary McGraw, *MAddison-Wesley Professional*.

1	**Code of the subject**	BCCS-9312
2	**Title of the subject**	Digital Watermarking & Steganalysis
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Mahua Bhattacharya
6	**Will this course require visiting faculty**	
7	**Learning Objectives of the subject**	The objective of the course makes students familiar about Digital watermarking and steganography.
8	**Brief Contents (module wise)**	**Module I-Introduction:** Information Hiding, Steganography, and Watermarking, Importance of Digital Watermarking, Steganography **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 **Module II-Models of Watermarking:** Communication-Based Models of Watermarking, Geometric Models of Watermarking, Modeling Watermark Detection by Correlation, **Basic Message Coding:** Mapping Messages into Message Vectors, Error Correction Coding, Detecting Multi-symbol Watermarks **Module III- Watermarking with Side Information:** Informed Embedding, Watermarking Using Side Information, Dirty-Paper Codes **Robust Watermarking:** Approaches, Robustness to Volumetric Distortions, Robustness to Temporal and Geometric Distortions **Module IV- Watermark Security:** Security Requirements, Watermark Security and Cryptography, Some Significant Known Attacks **Content Authentication:** Exact Authentication, Selective Authentication, Localization, Restoration, **Steganography:** Notation and Terminology, Information-Theoretic Foundations of Steganography, Practical Steganographic Methods, Minimizing the Embedding Impact **Steganalysis:** Steganalysis Scenarios, Some Significant Steganalysis Algorithms.
9	**Contents for lab (If applicable)**	
10	**List of text books/references**	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

Electives (AI & Robotics)

1	**Code of the subject**	BCCS-9401
2	**Title of the subject**	Microelectronics
3	**Any prerequisite**	Basic Electrical Engineering and Basic Electronics
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Manisha Pattanaik
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The course will provide adequate understanding of semiconductor devices and their modeling aspects, useful for designing devices in electronic circuits. Students will understand basic operation of semiconductor devices which will be foundational for the expansive semiconductor industry.
8	**Brief Contents (module wise)**	Introduction to semiconductor materials and their corresponding electronic devices and circuits; Physics of semiconductor materials, operation of semiconductor devices including diodes and transistors (MOSFETs) and application of MOSFETs into digital circuits. Trends in electronic circuits; Analysis and design of electronic circuits in bipolar and MOS technologies with emphasis on both large-signal and small-signal methods. Circuits for logic gates, latches and memories, single-stage and multistage amplifiers and opamps; Circuits with feedback, including stability and frequency response considerations, Analog and Mixed analog/digital circuit application and Circuit simulation with SPICE.
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	B. *Streetman* and S. Banerjee, Solid State Electronic Devices, 5th edition, Prentice Hall. Pucknell, D.A. and Eshraghian, K., "Basic VLSI Design", 3rd Ed., Prentice-Hall of India. Eshraghian, K., Pucknell, D.A. and Eshraghian, S., "Essentials of VLSI Circuit and System", 2nd Ed., Prentice-Hall of India. Uyemera, P.J., "Introduction to VLSI Circuits and Systems", 4th Ed., John Wiley & Sons.

1	**Code of the subject**	BCCS-9402
2	**Title of the subject**	Introduction To Robotics
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Ritu Tiwari
6	**Will this course require visiting faculty**	NA
7	**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.
8	**Brief Contents (module wise)**	**SystemsOverview of a Robot**, Mechanical Systems, Components, Dynamics and Modeling, Control of Actuators in Robotic Mechanisms, Robotic Sensory Devices. **PerformanceDefinition** - Accuracy/ Repeatability/ Precision with respect to Position &Path, payload, speed, acceleration, cycle time **Challenges/plicationsandusesofMobileandotherrobots**: wheeled, tracked, legged, aerial, underwater robots, surgical robots, rehabilitation robots, humanoidrobots **Introduction to robot manipulation**. Forward and inverse kinematics of robots and some case studies. Manipulator dynamics. Basics of robot control. **Taskplanning**with emphasis on computational geometry methods for robot path finding, robot arm reachability, grasp planning etc. **Overview of robot vision**.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	TEXT BOOKS: 1. Richard D. Klafter, Robotic Engineering: An Integrated Approach, Phi 2. R. J. Schilling, Fundamentals of Robotics: Analysis And Control, Prentice-Hall India References: 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**	BCCS-9403
2	**Title of the subject**	Embedded Robotics
3	**Any prerequisite**	Knowledge of microprocessor and digital circuits
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Sunil Kumar
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	After successful completion of this course, students will able to learn to develop a programmable embedded platform from scratch,interface a variety of sensors and actuators for interactive systems.In short, this course will provide hands-on course on the theory andpractice of developing real-time and embedded systems.
8	**Brief Contents (module wise)**	**Module-I** Introduction of Embedded System and Robotics, architectureand classifications of embedded systems. Fundamentals ofembedded processor and microcontrollers, CISC vs. RISC. **Module-II** Basics of Microcontrollers –timers, interrupts, analog-to digital conversion, AVR Microcontroller. **Module-III** Interface of LEDs, Motors, buzzers, LCDs, IR ensors, Relay, Keypad, Speakers, Temperature Sensors etc. **Module-IV** A brief introduction to Arduino, GPS and GSM **Module-V** Scheduling and Concurrency: Fixed and Dynamic, Synchronization problems, and communication.
9	**Contents for lab (If applicable)**	LED and Motor, Sensor, Robotics and Application-based Projects
10	**List of text books/references**	1. Shibu K V, Introduction to Embedded Systems 2. http://numericinfosystems.in

1	**Code of the subject**	BCCS-9404
2	**Title of the subject**	Mobile Robotics
3	**Any prerequisite**	Mathematics -I and Mathematics – II
4	**L-T-P**	3-0-0 (3 credit course)
5	**Name of the proposer**	Dr. W. Wilfred Godfrey
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To learn the math and computational methods necessary to model and solve kinematic problems involving robot manipulators and mobile robots ➢ To explore the computational challenges inherent in fundamental mobile robotic tasks (e.g. localization, mapping, motion planning)
8	**Brief Contents (module wise**	**Module I-Robot locomotion**: Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability **Module II -Mobile robot kinematics and dynamics**: Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots **Module III –Perception**: Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors formobile robots like global positioning system (GPS), Doppler effect-based sensors, vision based sensors, uncertainty in sensing, filtering **Module IV –Localization**: Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems **Module V- Introduction to planning and navigation**: path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP), stochastic dynamic programming (SDP)
9	**Contents for lab (If applicable)**	Nil
10	**List of text books/references**	1. R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011. 2. Peter Corke , Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011. 3. S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available online http://planning.cs.uiuc.edu/) 4. Thrun, S., Burgard,W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA, 2005. 5. Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds, 2012. 6. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005.

1	**Code of the subject**	BCCS-9405
2	**Title of the subject**	Introduction to Cognitive Science
3	**Any prerequisite**	BCCS-3202-Machine Learning
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Pinku Ranjan
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ Be competent with the interdisciplinary nature of cognitive science, the diversity of viewpoints, the controversies and the areas of nascent consensus. ➢ Be competent with reading and discussing research papers from multiple disciplines. ➢ Be familiar with brain anatomy and physiology. ➢ Be familiar with the basic cognitive architecture - how perception, memory, language, motor control, and so forth come together to produce adaptive behavior. ➢ Be familiar with the components of a grammar: phonology, morphology, syntax, and semantics. ➢ Be familiar with writing critical essays on topics outside ones area of specialization. ➢ Be exposed to each of the five constituent disciplines and be familiar with its methods, key concepts, and focus of investigation
8	**Brief Contents (module wise)**	➢ Introduction ➢ Philosophy: Overview. Nativism vs. empiricism. Mind-body problem. Functionalism. Turing Test. Modularity of mind. Consciousness. ➢ Neuroscience: Overview. Brain anatomy. Neuroimaging. Neurophysiology. Synaptic plasticity. Biological basis of learning. Brain damage. Amnesia. Aphasia. Agnosia. ➢ Artificial Intelligence: Overview. Turing machines. Physical symbol systems. Heuristic search. Connectionism. Machine Learning. ➢ Psychology: Overview. Behaviorism vs. cognitive psychology. Perception and psychophysics. Multiple memory systems. Executive control. High-level cognition. ➢ Linguistics: Overview, Components of a grammar. Phonology. Syntax. Compositionality, systematicity, and productivity. Semantics. Language acquisition. Is language innate? ➢ Integration: What is representation? Answers from all 5 disciplines. Cognitive architectures. ACT-R. Leabra. ➢ Robotics and Embodied Cognition: Overview. Symbol grounding. ➢ Advanced Topics
9	**Contents for lab (If applicable)**	No
10	**List of text books/references**	1. Cognitive Science: An Introduction to the Study of Mind Friedenberg& Silverman 2.ilson, Robert A., &Keil, Frank C. (eds.), The MIT Encyclopedia of the Cognitive Sciences (MITECS), MIT Press, 2001 [Primary text] 3. Evans, Vyvyan and Melanie Green; Cognitive linguistics: an introduction, Routledge, 2006.

1	**Code of the subject**	BCCS-9406
2	**Title of the subject**	Decision Making and Expert system
3	**Any prerequisite**	Artificial Intelligence
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Debanjan Sadhya
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• Design intelligent machines which emulate the decision-making ability of a human expert. • Understand intelligence by building computer programs that exhibit intelligent behaviour. • Present the basic components of expert systems and illustrate that how they are used for solving real-life complex problems.
8	**Brief Contents (module wise)**	**Module I**: Introduction: What is an Expert System?Why should we use Expert Systems? History of Expert Systems. **Module II**: Expert system architecture: knowledge base, working memory, inference engine, and system analysis, graphic and other software and userinterface. **Module III**: Knowledge base: Priori knowledge, Posteriori knowledge, Rules, Semantic nets, Frames, Scripts. **Module IV**: Inference engine: Forward chaining (Bottom – up reasoning), Backward chaining (Top-down reasoning), Abduction, Reasoning under uncertainty. **Module V**: Learning by induction: Learning by observation, Learning by discovery, Supervised learning, Learning from examples, Unsupervised learning. **Module VI**: Application of Expert systems: RADEX.
9	**Contents for lab (If applicable)**	N/A
10	**List of text books/references**	1."Expert Systems: The Technology of Knowledge Management for the 21st Century", Cornelius T. Leondes, *Academic Press*. 2. "Introduction To Expert Systems", Peter Jackson, *Addison Wesley*. 3."Decision support systems and intelligent systems", Efraim Turban, Jay E. Aronson, Ting-Peng Liang, *Prentice-Hall*.

1	**Code of the subject**	BCCS-9407
2	**Title of the subject**	Nature Inspired Computing
3	**Any prerequisite**	Basic Mathematics, Data Structures, and Algorithms
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Pramod Kumar Singh
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject**	➢ It introduces a new paradigm of computing and solving problems. ➢ It has great applications in Artificial Intelligence, Data Mining, Machine Learning, and real-world design and optimization problems.
8	**Brief Contents (module wise)**	**Module I: Introduction:** Introduction: Nature-inspired Computing, Evolutionary Computation, Swarm Intelligence, Artificial Neural Networks, Fuzzy Systems; Brief History. **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. **Module III: Artificial Neural network:** Introduction: Fundamental Concepts, Evolution, Basic Models, Terminology, McCulloh-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 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.
9	**Contents for lab**	No lab is associated with this course.
10	**List of text books/references**	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**	BCCS-9408
2	**Title of the subject**	Intelligent Systems and Interfaces
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Ritu Tiwari
6	**Will this course require visiting faculty**	
7	**Learning Objectives of the subject (in about 50 words)**	The overall goal of this course is to give the students the ability to design and program small expert system while building a base for advanced studies. Topics include programming techniques for expert system, the design and construction of expert system, the representation of knowledge, reasoning under uncertainty, inexact reasoning, classification, configuration and diagnosis system.
8	**Brief Contents (module wise)**	**TheTnatureTof ExpertTSystems**. TypesofapplicationsofExpertSystems; relationshipofExpertSystems toArtificialIntelligenceandto Knowledge-BasedSystems.The natureof expertise. DistinguishingfeaturesofExpertSystems. Benefitsofusing an Expert System. Choosing anapplication. **TheoreticalFoundations**, What anexpert systemis; how itworksand howit isbuilt, Basic formsofinference: abduction; deduction; induction. **Basiccomponentsof an expertsystem.** Generationofexplanations. Handlingofuncertainties. TruthMaintenanceSystems. **ExpertSystemArchitectures** An analysisof someclassic expertsystems. Limitationsof firstgeneration expertsystems. Deepexpertsystems. Co-operating expertsystems and theblackboardmodel. **Building Expert Systems** Methodologies forbuilding expertsystems: knowledgeacquisitionandelicitation; formalisation; representationand evaluation. KnowledgeEngineeringtools.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	**Text Books:** **1.** P Jackson, Introduction to Expert Systems, Addison Wesley 2. Donald A.Waterman, 'A Guide to Expert Systems', Pearson Education. **Reference Books:** 1. T. M. Mitchell, Machine learning, McGraw-Hill 1997. 2. J. Han and M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2000.

1	**Code of the subject**	BCCS-9409
2	**Title of the subject**	System Biology
3	**Any prerequisite**	NO
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Pinku Ranjan
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ appreciate the basic organization of organisms and living being. ➢ understand the machinery of the cell that is ultimately responsible for various daily activities. ➢ acquire knowledge about biological problems that requires engineering expertise to solve them.
8	**Brief Contents (module wise)**	***BASIC CELL BIOLOGY:*** Introduction to Biology**,** The cell: the basic unit of life**,** Expression of genetic information - protein structure and function**,** Cell metabolism; Cells respond to their external environments**,** Cells grow and reproduce**,** Cellular differentiation ***BIOCHEMISTRY AND MOLECULAR ASPECTS OF LIFE:*** Biodiversity - Chemical bonds in Biochemistry; Biochemistry and Human biology,Protein synthesis –DNA; RNA**,** Transcription and translation factors play key roles in protein synthesis**,** Differences between eukaryotic and prokaryotic protein Synthesis**,** Stem cells and their applications ***ENZYMES AND INDUSTRIAL APPLICATIONS:*** Enzymes – significance, factors**,** Mechanism and effective catalysis – proteases, carbonic anhydrase**,** Restriction Enzymes; Nucleoside Monophosphate Kinases**,** Photosynthesis and carbon fixation; Biological energy production**,** Metabolism-anabolism and catabolism ***MECHANOCHEMISTRY:*** Protein motors convert chemical energy into mechanical work**,** The bacterial flagellar motor**,** ATP synthase structure, Cytoskeleton, Biosensors - types, applications, Bioremediation ***NERVOUS SYSTEM, IMMUNE SYSTEM AND CELL SIGNALING:*** Basics of nervous system and "neural networks, The cellular basis of immunity, The functional properties and structure of antibodies, T cell receptors and subclasses, General principles of cell signaling
9	**Contents for lab**	NO
10	**List of text books/references**	1.ThyagaRajan.S., Selvamurugan. N., Rajesh.M.P.,Nazeer.R.A., Richard W. Thilagaraj, Barathi.S., and Jaganthan.M.K., "Biology for Engineers", Tata McGraw-Hill, New Delhi, 2012. 2.Jeremy M. Berg, John L. Tymoczko and LubertStryer, "Biochemistry", W.H. Freeman and Co. Ltd., 6th Ed., 2006. 3. Robert Weaver, "Molecular Biology", MCGraw-Hill, 5th Edition, 2012. 4. Jon Cooper, "Biosensors A Practical Approach", Bellwether Books, 2004. 5. Martin Alexander, "Biodegradation and Bioremediation", Academic Press, 1994. 6. Kenneth Murphy, "Janeway'sImmunobiology", Garland Science; 8th edition, 2011. 7. Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, "Principles of Neural Science", McGraw-Hill, 5th Edition, 2012.

1	**Code of the subject**	BCCS-9410
2	**Title of the subject**	Multi Agents and Application
3	**Any prerequisite**	Mathematics-I and II, Artificial Intelligence
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. W. Wilfred Godfrey
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To introduce the student to the concept of an agent and multi-agent systems, and the main applications for which they are appropriate; ➢ To introduce the main issues surrounding the design of intelligent agents and multi-agent society; ➢ To introduce a contemporary platform for implementing agents and multi-agent systems. ➢ To introduce other practical applications of multi-agent systems such as online advertising, online auction, adversarial training for generative models, bots planning, and AI agents playing online games etc.
8	**Brief Contents (module wise)**	**Module I-Introduction:** what is an agent,agents and objects; agents and expert systems; agents & distributed systems; typical application for agent systems. **Module II-Intelligent Agents:**The design of intelligent agents - reasoning agents (egAgentO), agents as reactive systems (egsubsumption architecture); hybrid agents (eg PRS); layered agents (egInterrap) a contemporary (Java-based) framework for programming agents (Jack language, the JAM system). **Module III-Multi-Agent Systems:** Classifying multi-agent interactions - cooperative versus non-cooperative; zero-sum & other interactions; what is cooperation? how cooperation occurs-Prisoner's dilemma and Axelrod's experiments; Interactions between self-interested agents: auctions & voting systems: negotiation; Interactions between benevolent agents: cooperative distributed problem solving (CDPS), partial global planning; coherence and coordination; Interaction languages & protocols: speech acts, KQML/KIF, FIPA framework. **Module IV -Single and Multi-agent reinforcement learning:** Value Iterations, Policy Iterations, Q-learning, Policy Gradient, and Deep Reinforcement Learning, Stochastic games, Nash-Q, Gradient Ascent, WOLF, and Mean-field Q learning **Module V –Applications:** Online advertising machine bidding, AI agents playing online games, and learning to collaborate for bots
9	**Contents for lab**	Nil
10	**List of text books/references**	1. Shoham, Yoav, Kevin Leyton-Brown. Multiagent systems: Algorithmic, game-theoretic, and logical foundations. Cambridge Univ. Press, 2008. 2.An Introduction to MultiAgent Systems - Second Edition. Michael Wooldridge Wiley, 2009. 3. Programming Multi-agent Systems in AgentSpeak Using Jason. Rafael H. Bordini, Jomi Fred Hubner and Michael Wooldridge Wiley, 2007. 4. Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence. Gerhard Weiss (Ed.), MIT Press, 1999.

1	**Code of the subject**	BCCS-9411
2	**Title of the subject**	Special topics in Artificial Intelligence
3	**Any prerequisite**	Prior to this course, it is assumed that students have a backgroundknowledge of linear algebra, and probability theory, and patternrecognition.
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Sunil Kumar
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	After successful completion of this course, students will ableexplore some advance topics of artificial intelligence (AI). Thiscourse mainly focuses on different state-of-the-art applications ofmachine learning, and hence familiarize the students with advancetopics of AI is the main objective of the course.
8	**Brief Contents (module wise)**	**Module-I** Overview of this course on Artificial Intelligence (AI): What and Why? AI vs Human brain. Introduction to deep convolutionneural network (CNN). **Module-II** Learning of Multi-layer perception, Stochastic gradient descent algorithm; Deep feed forward neural network and Regularization. **Module-III** The Convolution operations, Pooling, Basic architectureof CNN, Variants of the Basic Convolution Model-AlexNet, ResNetand Other architecture. **Module-IV** Sequence Modelling: Recurrent and Recursive Nets, Recurrent Neural Network, Language modelling and machine translation **Module-V** GAN and their Variants, R-CNN, You only Look Once (YOLO), and Single Shot Detector (SSD)
9	**Contents for lab (If applicable)**	Hands-on implementation of Deep architecture; Auto-encoder usingCNN; Object detection using CNN; Realistic image Generationusing GAN.
10	**List of text books/references**	Related research articles and important links

Electives (Visual Information Processing)

1	**Code of the subject**	BCCS-9501
2	**Title of the subject**	Information Retrieval and Extraction
3	**Any prerequisite**	-
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Jeevaraj S
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ To understand the theoretical basis behind the standard models of IR (Boolean, Vector-space, Probabilistic and Logical models), ➢ To understand the difficulty of representing and retrieving documents, images, speech, etc., ➢ To be able to implement, run and test a standard IR system, ➢ To be familiar with various IR algorithms and IR systems.
8	**Brief Contents (module wise)**	Vector Space Model Probabilistic Retrieval Strategies Language Models Inference Networks Extended Boolean Retrieval Latent Semantic Indexing Neural Networks Genetic Algorithms Fuzzy Set retrieval Fuzzy Information Retrieval System in Detail Relevance feedback Clustering Fuzzy Clustering Passage based Retrieval N-grams Cross-Language Information Retrieval Efficiency
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1.“Information Retrieval- Algorithms and Heuristics”, second edition by David A. Grossman and OphirFrieder. Publisher: Springer. 2.*“Modern Information Retrieval”*by R. Baeza-Yates and B. Ribeiro-Neto. 3. “Information Retrieval: Implementing and Evaluating Search Engines” by S. Büttcher, C. Clarke, and G. Cormack.

1	**Code of the subject**	BCCS-9502
2	**Title of the subject**	Image Processing
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. K. V. Arya
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	To introduce the basic concepts of Digital image processing with emphasis on applications in various field of recent research.
8	**Brief Contents (module wise)**	Module-I Introduction and Fundamentals Module-II Image Enhancement in Spatial Domain Module-III Image Enhancement in Frequency Domain Module-IV Image Restoration Module-V Segmentation Module-VI Representation and Description
9	**Contents for lab (If applicable)**	NA
10	**List of text books/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**	BCCS-9503
2	**Title of the subject**	Digital Watermarking & Steganalysis
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Mahua Bhattacharya
6	**Will this course require visiting faculty**	
7	**Learning Objectives of the subject (in about 50 words)**	The objective of the course makes students familiar about Digital watermarking and steganography.
8	**Brief Contents (module wise)**	**Module I** **Introduction:** Information Hiding, Steganography, and Watermarking, Importance of Digital Watermarking, Steganography **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 **Module II** **Models of Watermarking:** Communication-Based Models of Watermarking, Geometric Models of Watermarking, Modeling Watermark Detection by Correlation, **Basic Message Coding:** Mapping Messages into Message Vectors, Error Correction Coding, Detecting Multi-symbol Watermarks **Module III** **Watermarking with Side Information:** Informed Embedding, Watermarking Using Side Information, Dirty-Paper Codes **Robust Watermarking:** Approaches, Robustness to Volumetric Distortions, Robustness to Temporal and Geometric Distortions **Module IV** **Watermark Security:** Security Requirements, Watermark Security and Cryptography, Some Significant Known Attacks **Content Authentication:** Exact Authentication, Selective Authentication, Localization, Restoration, **Steganography:** Notation and Terminology, Information-Theoretic Foundations of Steganography, Practical Steganographic Methods, Minimizing the Embedding **Steganalysis:** Steganalysis Scenarios, Some Significant Steganalysis Algorithms.
9	**Contents for lab (If applicable)**	
10	**List of text books/references**	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**	BCCS-9504
2	**Title of the subject**	Pattern Recognition
3	**Any prerequisite**	Introductory courses on probability and linear algebra. Knowledgeof basic programming languages like C/C++, Matlab, etc.
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Sunil Kumar
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	After successful completion of this course, students should have a clear understanding of 1) The basic steps of pattern recognitionsystem 2) Need of feature extraction and feature selection: what andwhy?, 3) Dimensionality reduction, and 4) Finally, students shouldhave practical hands-on experience of implementing several patternrecognition techniques on real-time data.
8	**Brief Contents (module wise)**	**Module-I** Introduction to pattern recognition (PR), data-sets,paradigms of PR. Representations of Patterns and Classes, Decisionboundaries for binary-class/multi-class classification. problems. **Module-II** Supervised vs Unsupervised classification; Feature extractionand feature selection (dimensionality reduction). **Module-III** Bayesian Decision Theory, Linear Discriminant Function,Maximum Likelihood Estimation, and Bayesian ParameterEstimation and Support Vector Machines. **Module-IV** Non-Parametric Techniques: Nearest Neighbor Methodsand Parzen Window Method; **Module-V** Unsupervised Methods: PCA, LDA, LPP, K-means, andMean-shift algorithm. **Module-VI** State-space analysis: First-order Hidden Markov Models.
9	**Contents for lab (If applicable)**	Assignments required on implementations of Module-3, 4,5, and 6.
10	**List of text books/references**	1. Christopher Bishop. Pattern Recognition and Machine Learning, Second Edition 2. R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, Wiley, 2000. 3. Devi V.S.; Murty, M.N. (2011) Pattern Recognition: An Introduction, Universities Press, Hyderabad. 4. Lawrence R. Rabiner, Ronald W. Schafer, Digital Processing of Speech Signals.

1	**Code of the subject**	BCCS-9505
2	**Title of the subject**	Multimedia Systems
3	**Any prerequisite**	Knowledge of 1D and 2D signal processing
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Sunil Kumar
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The objective of this course is to familiarize the students with 1D/2Dsignal processing with their adequate applications in multimedia(tex/audio/video). Ranging from data sampling to image and videocompression, and securities are the attractions of this course. Thus,the package of this course enables the students to utilize the datain a efficient and in a more secure way.
8	**Brief Contents (module wise)**	**Module-I** Introduction to Multimedia System; what and why?Waveform of different types of signals and their basic operations.Signal generation, Sampling, Quantization, and Reconstruction. **Module-II** Frequency-domain signal processing: discrete-timeFourier Transform, DFT for 1D/2D. Magnitude and phase spectrum, Time-frequency representation, Filters. **Module-III** Discrete Cosine Transform: 1D DCT and 2D DCT, PerformingDCT Computations, Compression with DCT, Separability,2D DCT on Image Blocks, 2D DCT Basis Functions. **Module-IV** Image acquisition and representation, Color modelsimage compression standards: JPEG image compression (lossyvs lossless) standards, MPEG, H.264/AVC, video compressionsstandards. **Module-V** Fundamentals of data communication and networking,Bandwidth requirements of different media, Real time onstraints:latency, video data rate, multimedia over LAN and WAN, Multimedia conferencing, video-on-demand broadcasting issues. **Module-VI** Information theory: entropy, Shannon's concept of information,Different Coding schemes.
9	**Contents for lab (If applicable)**	Nil
10	**List of text books/references**	1. Jerry D. Gibson, Toby Berger, Tom Lookabaugh, Dave Lindergh andRichard L. Baker Digital Compression for Multimedia: Principles andStandards Elsevier, 2006. 2. Fundamentals of Multimedia: Ze-Nian Li and Mark S. Drew, Pearson Prentice Hall, 2004 3. Ralf Steinmetz and Klara Nahrstedt, Multimedia: Computing, Communications, and Application, Prentice Hall, 1995 4. Khalid Sayood Introduction to Data Compression 3rd Edition, Elsevier, 2006.

1	**Code of the subject**	BCCS-9506
2	**Title of the subject**	Human Computer Interaction
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Mahua Bhattacharya
6	**Will this course require visiting faculty**	
7	**Learning Objectives of the subject (in about 50 words)**	The course is intended to introduce the student to the basic concepts of human-computer interaction. It will cover the basic theory and methods that exist in the field. The course will unfold by examining design and evaluation.On completion of this course according to course goals, the student should be able to:understand the basics of human and computational abilities, limitations. • understand basic theories, tools and techniques in HCI. • understand the fundamental aspects of designing and evaluating interfaces. • practice a variety of methods for evaluating quality of a user interface. • apply appropriate HCI techniques to design systems that are usable by people.
8	**Brief Contents (module wise)**	**Module I: Foundations of Human–Computer Interaction**: Human Capabilities, The Computer, The Interaction, Paradigms **Module II: The Design Process**: Interaction Design Basics, HCI in the Software Process, Design Rules, Universal Design **Module III: Implementation Support**: Implementation Tools **Module IV: Evaluation and User Support:** Evaluation, User Support **Module V: Users Models:** Cognitive Models, Socio-organizational Issues and Stakeholder Requirements **Module VI: Task Models & Dialogs:** Analyzing Tasks, Dialog Notations **Module VII: Groupware, Ubiquitous Computing, Virtual and Augmented Reality, Hypertext and Multimedia:** Groupware & Computer-supported Collaborative Work, Ubiquitous Computing, Virtual Reality& Augmented Reality, Hypertext, Multimedia and World Wide Web
9	**Contents for lab (If applicable)**	During the course the students will be involved with a real problem solving/software development project. Students will be required to gather functional requirements, identify the problem, form a solution and present this solution.
10	**List of text books/references**	1.Alan Dix , Janet E. Finlay, Gregory D. Abowd, Russell Beale, Human - Computer Interaction Harlow, England: Prentice Hall, 2. Yvonne Rogers, Helen Sharp, Jenny Preece, Interation Design: Beyond Human Computer Interaction, 3rd Edition, Wiley, 20111

1	**Code of the subject**	BCCS-9507
2	**Title of the subject**	Computer Vision
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Mahua Bhattacharya
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	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.
8	**Brief Contents (module wise)**	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
9	**Contents for lab (If applicable)**	Basics of transformation, Filters, edge detection techniques, Caney, Sobel, Prewitt ,K-Means, K-Medoids Clustering, Convolution and Filtering, Image Enhancement, Histogram, Image Segmentation
10	**List of text books/references**	1.Digital Image Processing, 3rd Edition Rafael C. Gonzalez, University of Tennessee, Richard E. Woods, Med Data Interactive 2.Computer Vision: A Modern Approach; D. A. Forsyth and J. Ponce; Pearson Education; 2003. 3. Computer Vision: Algorithms and Applications" by Richard Szeliski; Springer-Verlag London Limited 2011.

1	**Code of the subject**	BCCS-9508
2	**Title of the subject**	Digital Signal Processing
3	**Any prerequisite**	Signal & System
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Vinal Patel
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ 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.
8	**Brief Contents (module wise)**	**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. **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, inverse z-transform methods,pole-zero plots, RoC implications of causality and stability. **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. **Module IV:** Discrete Fourier Transform (DFT): Definition of the DFT and inverse DFT-circular shift of signal and the "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.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. Discrete-Time Signal Processing by Alan V. Oppenheim and Ronald W. Schafer, 3rd edition, 2010, Prentice Hall, Upper Saddle River, NJ. 2. Digital *Signal Processing* by SanjitMitra, 4th edition, 2011, McGraw-Hill, New York, NY.

Electives (VLSI & Nanotechnology)

1	**Code of the subject**	BCCS-9601
2	**Title of the subject**	Introduction to Nanoscience and Nanotechnology
3	**Any prerequisite**	Basic knowledge in Physics, Chemistry, Mathematics and Biology.
4	**L-T-P**	3-0-1
5	**Name of the proposer**	Anurag Srivastava
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• This course will focus on developing better understanding of emerging low dimensional novel materials such as carbon nanotubes, graphene and other than graphene based transistors and developing models for designing of ultra-low energy nanoscale-integrated electronic and nano-photonic circuits. • On-chip VLSI interconnect based on carbon nanotubes, graphene nanoribbon and hybrid materials will be introduced for possible replacement of copper interconnect in nm CMOS technologies, as part of applications.
8	**Brief Contents (module wise)**	**Background to Nanoscience:** Defination of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challengs of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties. **Types of nanostructure and properties of nanomaterials:** One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties. **Application of Nanomaterial**: coating, molecular electronics and nanoelectronics, biological and environmental, membrane based application, polymer based application,Energy Devices, especially the solar cell, supercapacitors, batteries etc.
9	**Contents for lab (If applicable)**	Hands on tool QuantumATK-VNL for electronic and transport properties of Nano materials
10	**List of text books/references**	1. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al. 2. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004. 3. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press. 4. Processing & properties of structural naonmaterials - Leon L. Shaw, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.

1	**Code of the subject**	BCCS-9602
2	**Title of the subject**	VLSI Design
3	**Any prerequisite**	Familiarity with circuits, logic and digital system design
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. Manisha Pattanaik
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The main objective of this course is to provide in-depth understanding of the VLSI Design flow from RTL to layout, and applications of CAD tools and timing simulations.
8	**Brief Contents (module wise)**	Introduction to VLSI Systems: VLSI overview, VLSI designs flow, design hierarchy, VLSI design styles. Semiconductor technology trends and impact on VLSI architecture and design; Methodologies for VLSI structured design: Design analysis and simulation, Design Verification, Implementation approaches, Design synthesis, Validation and testing of integrated circuits. VLSI system design and optimizations for performance and power Design for test Case Studies: Application of CAD tools to design VLSI system based on above concepts. Students will be exposed to the state-of-the art CAD tools and VLSI system design methods.
9	**Contents for lab (If applicable)**	NIL
10	**List of text books/references**	1. "Principles of CMOS VLSI Design", Neil H. E. Weste, Kamran Eshraghian, Addison Wesley. 2. "CMOS Digital Integrated Circuits: Analysis and Design," Sung-Mo Kang And Yusuf Leblebici. 3. Pucknell, D.A. and Eshraghian, K., "Basic VLSI Design", 3rd Ed., Prentice-Hall of India. 4. Eshraghian, K., Pucknell, D.A. and Eshraghian, S., "Essentials of VLSI Circuit and System", 2nd Ed., Prentice-Hall of India. 5. Uyemera, P.J., "Introduction to VLSI Circuits and Systems", 4th Ed., JohnWiley&Sons.

1	**Code of the subject**	BCCS-9603
2	**Title of the subject**	VLSI Testing and Fault Tolerance
3	**Any prerequisite**	Digital Design, CAD for VLSI
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. G.K. Sharma
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The main objective of this course is to provide in-depth understanding of the problems encountered in testing large circuits, approaches to detect and diagnose the faults and methods to improve the design to make it testable. The students will be able to develop algorithms and tools for VLSI testing, designing of testable circuits. The scope of this course is to particularly address the challenges in the VLSI testing domain and get students motivated towards research in this field.
8	**Brief Contents (module wise)**	**Unit I: Introduction and Fault Modeling:** Testing problem, economics of testing, approaches to testing, fault-analysis and fault-models, analysis at component level, gatelevelandfunctionalblocklevel.Physicalfaultmodel,stuck-atfaultmodel,stuck- open and bridgingfault-model. **Unit II: Testing Techniques:** Algebraic and structural testing methods, path sensitization, Boolean difference. Test Generation of Combinational Circuits: D-algorithm, PODEM, FAN, SOCRATES, static, dynamic and recursive learning. Test Generation of Sequential Circuits: Time frame expansion methods, forward-time, reverse-time, initialization and PSI problem, Fastest and Hitest. Parallel processing techniques for test generation, Boolean Satisfiability, transitive-closure based and Neural Network based approaches. **Unit III: Fault Simulation:** Serial, parallel, deductive and concurrent fault simulation, parallel pattern single fault propagation method, hierarchical fault simulation. **Unit IV: Design for Testability and Built-in-self-test:** Controllability and observability measures,TEMEAS,SCOAP,ad-hocdesignfortestabilitytechniques,fullscan,partial scan and boundary scan techniques, built-in-logic-block-observer (BILBO), linear feedbackshiftregister(LFSR),theoryofLFSRs, pseudo randomandweightedrandom testing, built-in-self-test(BIST). **Unit V: Fault Tolerance in VLSI:** Basic concepts and need of fault tolerance, various fault-tolerant techniques of designing fault-tolerant VLSI circuits, Networks-on-Chip (NoCs) for designing many-core systems, developing tools and techniques for designing fault-tolerant many-core systems.
9	**Contents for lab**	Not applicable
10	**List of text books/references**	**1.** MironAbramovici,MelvinA.BreuerandArthurD.Friedman,"*DigitalSystem Testing and Testable Design*", IEEE Press and also available from Jaico Publication House, 2001. **2.** MichaelL.BushnellandVishwaniD.Agrawal,"*EssentialofElectronicTesting for Digital, Memory and Mixed-Signal VLSI Circuits*", Kluwer Academic Publishers,2002. **3.** Dhiraj K. Pradhan, "*Fault-Tolerant Computing*", Vol. 1, Prentice-Hall,1986 **4.** Instructor slides to be distributed inclass. **5.** Research papers published in *IEEE Trans. on CAD of ICs, IEEE Design &Test of Computers, Proceedings IEEE, Test, DAC, DATE, ASP-DAC, VLSID conferences.*

1	**Code of the subject**	BCCS-9604
2	**Title of the subject**	CAD for VLSI
3	**Any prerequisite**	Digital Design, Data Structures and Algorithms
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. G.K. Sharma
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The main objective of this course is to provide in-depth understanding of the theoretical as well as practical concepts of the design and development of CAD tools for VLSI design. The students will be able to identify and develop new CAD tools for VLSI design. The scope of this course is to visualize new Design Automation (DA) research problems in view of the challenges of designing multi-core and/or many- core system-on-chip in the nanometer regime.
8	**Brief Contents (module wise)**	**Unit I: Introduction to VLSI-CAD:** VLSI design flow, Gasjki's Y-chart, challenges, motivating factors and recent trends in design automation research. VLSI design styles: full-custom, standard-cell, gate-array, macro-cell, module generation, PLAs and FPGAs. **Unit II: Digital hardware modeling:** Logic and system level modeling, functional and structural models, level of modeling, hardware description languages, benchmark circuits (ISCAS'85 and ISCAS'89). **Unit III: Simulation based design verification:** Types of simulation, complied code simulation, event-driven simulation, delay models, gate-level event-driven simulation, design and development of simulation tools, graph data structure and algorithms for VLSI-CAD. **Unit IV: High-level synthesis:** Logic synthesis, high-level synthesis design flow,design capture, data and control graph generation, resource allocation, operation scheduling algorithms, ASAP, ALAP, resource occupancy, mobility, time constraints and resource constraints scheduling, resource binding, data life-time, left-edge algorithm, task to agent problem, function unit binding, port binding, data path and control pathgeneration. **Unit V: Physical design automation:** Difficulties in physical design, circuit partitioning, deterministic and stochastic algorithms for circuit portioning, Kernighan-Lin algorithm, simulated annealing, floor-planning, model and cost functions, slicing and non-slicing floorplans, polar graphs and adjacency graphs for floorplans, various approaches to floorplanning, placement and routing. **Unit VI: CAD for Approximate Arithmetic Circuits:** Design of approximate arithmetic unitse.g.adders,multipliers,ALU,approximationviadifferenttechniquessuchasbit-truncation, voltage-overscaling, SPAA designmetrics. **Unit VII: Interconnection Networks and Network-on-Chip (NoC):** Introduction to multistage interconnection network, omega network, blocking mechanism, basic network topologies, NoC as a future SoC paradigm, NoC topologies, mapping of IPs, routing algorithms, CAD tool development for NoC designs, benchmarks for real-world applications such as multimedia system, telecom, office automation.
9	**Contents for lab**	Not applicable

10	**List of text books/references**	1. Giovanni De Micheli, *Synthesis and Optimization of Digital Circuits*,Tata McGraw Hill,1994 2. D.D Gajski et al., *High Level Synthesis: Introduction to Chip andSystem Design*, Kluwer Academic Publishers,1992 3. B. Parhami, *Computer Arithmetic: Algorithms and Hardware Designs*. Oxford, U.K.: Oxford Univ. Press, 2000, pp.93–96. 4. N. Zhu et. al. *Design of low-power high-speed truncation-error-tolerant adder and its application in digital signal processing*. IEEE Trans. onVLSI systems, 18(8):1225 –1229, Aug.2010. 5. A.B. Kahng and S. Kang, "Accuracy-configurable adder for approximate arithmetic designs," in *Proc. DAC*, pp. 820-825,2012. 6. S.M. Sait and H. Youssef, "*VLSI physical design automation: theory and practice*", World Scientific Pub. Co.,1999. 7. N.A. Sherwani, *Algorithms for VLSI Physical Design Autmation*, Kluwer AcademicPublisher 8. M. Sarrafzadeh and C.K. Wong, *An Introduction to VLSI PhysicalDesign*, McGraw Hill,1996 *9.* Current Literature: *IEEE Trans. on CAD of ICs, IEEE Trans. on VLSI Systems, ACM TODAES, Proceedings IEEE, DAC, DATE, ICCAD, ICCD, ASP-DAC,VLSID*

1	**Code of the subject**	BCCS-9605
2	**Title of the subject**	Nano electronics
3	**Any prerequisite**	Basic physics of Materials and Devices at Nanoscale
4	**L-T-P**	3-0-1
5	**Name of the proposer**	Anurag Srivastava
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	• This course will focus on developing better understanding the new perspective connecting the quantized conductance of short ballistic conductors to the familiar Ohm's law of long diffusive conductors, along with a brief description of the modern nanotransistor. • The major objectives are to provide students with knowledge and understanding of nano- electronics as an important interdisciplinary subject. • To have better understanding of electronics devices at quantum scale.
8	**Brief Contents (module wise)**	***Introduction:***Device scaling, Impact of scaling and its limitations, Moore's law, role of quantum mechanics. ***Mesoscopic observables:*** Ballistic transport, phase interference, universal conductance fluctuations, weak localization; Carrier heating; ***Quantum Mechanics :*** Basic Quantum mechanics and Fermi statistics, Metals, Insulators and Semiconductor, Density of states (DOS) in 0D-3D, DOS in disordered materials, ***Physics of nanoelectronics devices***: concept of HOMO and LUMO, band gap etc. ;Two terminal device model: Current flow in the presence of a bias, numerical technique for self-consistent estimation of V-I ,Current flow, quantum of conductance, Landauer theory; Field Effect Transistors (FETs): Ballistic quantum wire FETs, conventional MOSFETs, CMOS, short channel and narrow width, hot electron effect, punch-through and thin gate oxide breakdown. ***Non-Classical Devices***: Single Electron Transistors, Resonant Tunneling Devices, Gate Around Silicon Nanowire Transistors, III-V Material Nanowire Transistors ***CNT, GNR, and Hybrid Materials –based Interconnects, Sensors and Energy Devices***
9	**Contents for lab (If applicable)**	Hands on tool QuantumATK-VNL for electronic and transport properties of materials and devices.
10	**List of text books/references**	1.S. Datta, Electronic Transport in Mesocopic Systems; Cambridge University Press (1995). 2. S. Datta, Quantum Transport: Atom to Transistor; Cambridge University Press (2005). 3. David Ferry, Transport in Nanostructures Cambridge University Press (1995).

1	**Code of the subject**	BCCS-9606
2	**Title of the subject**	Synthesis of Digital Systems
3	**Any prerequisite**	Data Structures and digital circuit design
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Sunil Kumar
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	After successful completion of this course, students will able to understand techniques for digital system behavioural synthesis, verification and performance evaluation. Analysis and synthesis ofmodern System-on-Chip design methods are the main goal of thiscourse.
8	**Brief Contents (module wise)**	**Module-1** Introduction to Digital Circuits, Analog, Discretetime andDigital signals. Logic Gates, ROM, Design of PAL, PLA, Designusing Programmable Logic Devices. **Module-2** Review of hardware description languages and VHDL, Behaviour and Structure of VHDL. Data and control flow representations,Data flow graph (DFG) and Control data flow graph(CDFG) descriptions **Module-3** Introduction to High-level Synthesis: Design space exploration,Constructive vs. transformational/iterative techniques, Behaviouraloptimisation, Scheduling, allocation, module binding andcontroller synthesis, Register Allocation and Timing Issues. **Module-4** Finite State Machine Synthesis, Logic Synthesis and Binary Decision Diagrams, Scheduling and binding algorithms. **Module-5** Technology Mapping, Timing Analysis,and Physical Synthesis, Design for Testability, on-line test.
9	**Contents for lab (If applicable)**	Nil
10	**List of text books/references**	1. Giovanni de Micheli, Synthesis and Optimization of Digital Circuits, McGraw Hill 2. Morris Mano and Michael D. Ciletti, ”Digital Design”, 4thEd., Pearson Education, 2008 3. C.H. Roth, ”Fundamentals of Logic Design”, 5th Ed.,Cengage Learning, 2004

1	**Code of the subject**	BCCS-9607
2	**Title of the subject**	Integrated Circuit Technology
3	**Any prerequisite**	NIL
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Gaurav Kaushal
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	This course will introduce the student to the world of semiconductor IC technology fabrication. The course will also provide a comprehensive flavor of advanced device fabrication techniques, the effect of parasitics and process variations on device performance.
8	**Brief Contents (module wise)**	Modern Semiconductor IC fabrication Industrial/Academic Landscape; Overview of modern CMOS process flow – basic steps; Lithography; Oxidation; Diffusion; Ion-Implantation; Effects of device parasitic and process variations on device and circuit performance; Advanced device fabrication
9	**Contents for lab (If applicable)**	No
10	**List of text books/references**	1. Silicon VLSI Technology: Fundamentals, Practice, and Modeling, by Plummer, Deal, Griffin, Prentice Hall, 2000. 2. VLSI Fabrication Principles: Silicon and Gallium Arsenide, by Gandhi, S. K., John Wiley and Sons, 2003.

1	**Code of the subject**	BCCS-9608
2	**Title of the subject**	Memory Design
3	**Any prerequisite**	NIL
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Gaurav Kaushal
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	The objective of the Memory Design is to acquaint the students with memory cell, memory peripherals, novel SRAM cell, next-generation memory and memory array. The subject gives the platform to analyze the read/write/hold operations of different memory structures using CAD tools.
8	**Brief Contents (module wise)**	Overview of volatile memory, non-volatile memory, on-chip memory, on-chip memory types. Review of CMOS circuit design, sensing circuitry basics, read/write assist circuitry and other peripheral circuitries, next generation SRAM cell. Introduction to DRAM, high speed DRAM architectures, open and folded arrays organizations, bandwidth, latency, and cycle time, power, timing circuits. STT-MRAM, data migration policy for hybrid cache. Operation of FLASH memories (FLASH array sensing and programming), Charge Pump circuits.
9	**Contents for lab (If applicable)**	No
10	**List of text books/references**	1) VLSI Memory Chip Design, by KiyooItoh, Springer, 2001. 2) Ultra-low Voltage Nano-scale Memories, by KiyooItoh, Masashi Horiguchi, Hitoshi Tanaka, Springer, 2009. 3) Semiconductor Memories: Technology, Testing, and Reliability, by Ashok K. Sharma, Wiley IEEE, 2013. 4) Semiconductor Memories: A Handbook of Design, Manufacture and Application, by Betty Prince, Wiley, 2nd Edison, 1996. 5) DRAM Circuit Design: Fundamental and High-Speed Topics, by Keeth, Baker, Johnson, and Lin, Wiley, IEEE 2007.

1	**Code of the subject**	BCCS-9609
2	**Title of the subject**	Low Power VLSI Design
3	**Any prerequisite**	NO
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Pinku Ranjan
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ Identify clearly the sources of power consumption in a given VLSI Circuit ➢ Analyze and estimate dynamic and leakage power components in a DSM VLSI circuit ➢ Choose different types of SRAMs/ DRAMs for Low power applications ➢ Design low power arithmetic circuits and systems ➢ Decide at which level of abstraction it is advantageous to implement low power techniques in a VLSI system design
8	**Brief Contents (module wise)**	➢ Introduction, Sources of Power Dissipation, Static Power Dissipation, Active Power ➢ Dissipation Designing for Low Power, Circuit Techniques for Leakage Power Reduction ➢ Standard Adder Cells, CMOS Adders Architectures, Low Voltage Low Power Design Techniques, Current Mode Adders ➢ Types of Multiplier Architectures, Braun, Booth and Wallace Tree Multipliers and their performance comparison ➢ Sources of power dissipation in SRAMs, Low power SRAM circuit techniques, Sources of power dissipation in DRAMs, Low power DRAM circuit techniques ➢ The increased delays of wires, New materials for wires and dielectrics, Design methods taking into account interconnection delays, Cross talk ➢ Basic background on testing, Unsuitable design techniques for safety-critical applications, ➢ Low power and safely operating circuits, Case study – A Low power subsystem design
9	**Contents for lab (If applicable)**	NO
10	**List of text books/references**	1.Kiat Seng Yeo and Kaushik Roy, Low- Voltage, Low-Power VLSI Subsystems, Edition 2009, Tata McGraw Hill 2. Soudris D, Piguet C and Goutis C, Designing CMOS Circuits for Low Power, Kluwer Academic Publishers, 2002

1	**Code of the subject**	BCCS-9610
2	**Title of the subject**	Energy Aware Computing
3	**Any prerequisite**	computer-architecture and design
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Binod Prasad
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	➢ The course is intendedto give an overview of the energy-dissipation aspects of computers and computing. To learn various power and energy consumption modeling and analysis. To make use of energy aware approach in different areas e.g., data center, storage system, and wireless networking .
8	**Brief Contents (module wise)**	**Module I:** Introduction, Power consumption basics, Regulations and industry initiatives- Government, Industry, Approaches for energy efficient computing- Product longevity, Algorithmic efficiency, Resource allocation, Green Assets: Buildings, Data Centers, Networks, Devices, Computer and Earth Friendly peripherals. **Module II:** Virtualization: Green Maturity model for Virtualization, Virtualization level, energy efficient storage: power efficient storage system, energy saving technique for disk storage, Efficient-Efficient Data Centers and servers, Thin Clients: Introduction and Characteristics, Dynamic Voltage/Frequency Scaling in microprocessor and small handheld gazettes. **Module III:** Middleware Support for green computing, Tools for monitoring, HPC computing, Green Mobile- Energy Management in Mobile Systems and Smartphones, Greening Desktop and Laptop PCs, embedded computing and networking, Management Frameworks Standards and metrics for green computing, power measuring and profiling: Profiling Energy Usages for the Application and the operating System, Extra Energy usages profile. **Module IV:** Green Networking:algorithmic aspects of energy aware computing, Energy aware Infrastructure and Application, the Environmentally Responsible Business Strategies (ERBS)-Case Studies-Applying Green IT Strategies and Applications to a Home, Hospital, Packaging Industry and Telecom Sector.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. I. Ahmad, S. Ranka, "Handbook of Energy-Aware and Green Computing", CRC Press. 2.F. Richard Yu, Xi Zhang, Victor C.M. Leung, "Green Communications and Networking", CRC Press 3. BhuvanUnhelkar, ―Green IT Strategies and Applications-Using Environmental Intelligence‖, CRC Press, June 2011.

1	**Code of the subject**	BCCS-9611
2	**Title of the subject**	Molecular Nanoelectronics
3	**Any prerequisite**	Semiconductors; electronic materials properties, Microelectronics
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Anurag Srivastava
6	**Will this course require visiting faculty**	Yes/No
7	**Learning Objectives of the subject (in about 50 words)**	The main goal of this subject is to understand molecular level scaling of electronic components. To have insight into new generation of ultralow-cost, lightweight and flexible electronic devices. Study, modeling and simulation of organic material based devices and circuits. Acquaint the students with the conducting polymers, small-molecules, organic materials, different structures of OFETs, OLEDs and various applications of organic thin film transistors.
8	**Brief Contents (module wise)**	**Organic and Inorganic Materials & Charge Transport**: Introduction; Organic Materials:Conducting Polymers & Small Molecules, Organic Semiconductors:*p*-type, *n*-type, Ambipolar Semiconductors, Charge Transport in Organic Semiconductors, Charge Transport Models, Energy Band Diagram, Organic&inorganic materials for: Source, Drain & Gate electrodes, Insulators,Substrates;Comparisonbetween Organic&Inorganic Semiconductors. **Organic Thin Film Transistors and Applications:** Overview of Organic Field Effect Transistor (OFET); Operating Principle; Classification of Various Structures of OFETs; Output & Transfer Characteristics; OFETs Performance Parameters: Impact of Structural Parameters on OFET; Extraction of Various Performance Parameters, Advantages, Disadvantages & Limitations. **Organic Device Modeling and Fabrication Techniques**: Modeling of OTFT Different Structures, Origin of Contact Resistance, Contact Resistance Extraction, Analysis of OFET Electrical Characteristics, Validation and Comparison of OFETs. Organic Devices and Circuits Fabrication Techniques. **OLEDs and Organic Solar Cells:** ***Organic Light Emitting Diodes (OLEDs)****:* Introduction; Different Organic Materials for OLEDs; Classification of OLEDs, Output and Transfer Characteristics; Various Optical, Electrical and Thermal properties, Advantages, Disadvantages and Limitations. ***Organic Solar Cells***: Introduction, Materials, various properties, Characteristics, Advantages, Disadvantages and Limitations and Applications;
9	**Contents for lab (If applicable)**	Hands on tool QuantumATK-VNL for electronic and transport properties of organic materials and devices (Solar Cell, LEDs, MTJs, SETs etc.)
10	**List of text books/references**	1. Hagen Klauk, Organic Electronics: Materials, Manufacturing and Applications, Wiley-VCH VerlagGmbh& Co. KGaA, Germany. 2006 2. Klaus Mullen, UllrichScherf, Organic Light Emitting Devices: Synthesis, Prop.&App.,Wiley-VCH VerlagGmbh& Co. KGaA, Germany. 2005 3. Hagen Klauk, Organic Electronics II: More Materials and Applications, Wiley-VCH VerlagGmbh& Co. KGaA, Weinheim, Germany, 2012 4. Flora Li, Arokia Nathan, Yiliang Wu, Beng S. Ong, Organic Thin Film Transistor Integration:A Hybrid Approach, Wiley-VCH, Germany; 1st Ed. 5. Wolfgang Brutting, Physics of Organic Semiconductors, Wiley-VCH VerlagGmbh& Co. KGaA, Germany. 2005 6. Dresselhaus, MS, Dresselhaus, G & Avouris,P, Carbon Nanotubes: Synthesis, Structure, Prop. &App. New York: Springer- Verlag

Electives (Computer Architecture and System Design)

1	**Code of the subject**	BCCS-9701
2	**Title of the subject**	Advanced Computer Architecture
3	**Any prerequisite**	Computer Organization and Architecture
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Prof. K. V. Arya
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	To expose the students with different paradigm of the computer architecture, parallel architecture, performance evaluation of computer systems, cost to performance analysis of computer systems
8	**Brief Contents (module wise)**	Module-I Instruction Set Principles and Examples Module-II Cache and Memory Hierarchy Design Module-IIIParallel Processing and Architecture Module-IV Parallelism through Pipelining Module-VHardware and Software for VLIW and EPIC
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. R. Y. Kain, Advanced Computer Architecture, Pearson 2. K. Hwang and F. A. Briggs, Advanced Computer Architecture and Parallel Processing, McGraw Hill 3. D. A. Patterson and L.J. Hennessy, Advanced Computer Architecture, Morgan Kaufmann

1	**Code of the subject**	BCCS-9702
2	**Title of the subject**	Cyber Physical System Design
3	**Any prerequisite**	Computer Architecture
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Debanjan Sadhya
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• Develop an exposition of the challenges in implementing a cyber-physical system from a computational perspective, but based equally on the principles of automated control. • Expose the student to real world problems in this domain and provide a walk-through the design and validation problems for such systems.
8	**Brief Contents (module wise)**	**Module I**:Introduction:Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS, Industry 4.0, AutoSAR, IIOT implications, Building Automation, Medical CPS. **Module II**: Platform components: CPS HW platforms - Processors, Sensors, Actuators, CPS Network - WirelessHart, CAN, Automotive Ethernet, CPS Sw stack - RTOS, Scheduling Real Time control tasks. **Module III**: Principles of Automated Control Design: Dynamical Systems and Stability, Controller Design Techniques, Stability Analysis: CLFs, MLFs, stability under slow switching, Performance under packet drop and noise. **Module IV**: Formal Methods for Safety Assurance of CPS: Advanced Automata based modeling and analysis - Basic introduction and examples, Timed and Hybrid Automata, Formal Analysis -Flowpipe construction, reachability analysis. **Module V**: Secure Deployment of CPS: Attack models, Secure task mapping and Partitioning, State estimation for attack detection, Automotive Case study: Vehicle ABS hacking, Power Distribution Case study: Attacks on SmartGrids. **Module VI**: CPS case studies and tutorial, Automotive: SW controllers for ABS, ACC, Lane Departure Warning, Suspension Control, Healthcare: Artificial Pancreas/Infusion Pump/Pacemaker, Green Buildings: automated lighting, AC control.
9	**Contents for lab (If applicable)**	N/A
10	**List of text books/references**	1."Embedded Systems Foundations of Cyber-Physical Systems",Peter Marwedel,*Springer*. 2."Principles of Cyber-Physical Systems", Rajeev Alur, *MIT Press*. 3. "Computational Foundations of Cyber Physical Systems" (IIT KGP Course), SoumyajitDey (http://cse.iitkgp.ac.in/~soumya/cps/cps.html)

1	**Code of the subject**	BCCS-9703
2	**Title of the subject**	System-on-Chip Design
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Binod Prasad
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ This course is intended for students to learn how Systems-on-Chip (SoC) are designed at the system-level. To gain knowledge of SOC architecture and its modeling with the emphasis on hardware and software co-design and co-simulation.
8	**Brief Contents (module wise)**	**Module I:** Introduction and overview, Verilog RTL Design with examples. Simulation styles (fluid flow versus eventing). Basic RTL to gates synthesis algorithm. Using signals, variables and transactions for component inter-communication. SystemC overview. Structural hazards, retiming, refactoring. **Module II:** SOC design process, Hardware/software co-design: partitioning, real-time scheduling, hardware acceleration, Memory maps. Programmer's model. Firmware development. Transactional modeling, Virtual prototyping: electronic system-level languages and hardware/software co-simulation. **Module III:** Assertion based design: testing and synthesis. PSL/SVA assertions. Temporal logic compilation to FSM. Glue logic synthesis, High-level synthesis: allocation, scheduling and binding algorithms for C-to-RTL synthesis; **Module IV:** SoC integration: SoC communication architectures, IP interfacing, verification and test.
9	**Contents for lab (If applicable)**	
10	**List of text books/references**	1. G. De Micheli, *Synthesis and Optimization of Digital Circuits*, McGraw-Hill, 1994. 2. F. Ghenassia, “Transaction-level modeling with SystemC: TLM concepts and applications for embedded systems”, Springer, 2010. 3. D. Gajski, S. Abdi, A. Gerstlauer, G. Schirner, *Embedded System Design: Modeling, Synthesis, Verification*, Springer, 2009.

1	**Code of the subject**	BCCS-9704
2	**Title of the subject**	On-Chip Interconnection Networks
3	**Any prerequisite**	Integrated Circuit Technology
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Vinal Patel
6	**Will this course require visiting faculty**	No
7	**Learning Objectives of the subject (in about 50 words)**	➢ This course examines the architecture, design methodology, and trade-offs of interconnection networks. ➢ The overall focus of the course will be on interconnection network architectures used in multiprocessor and many-core systems, and designing for the communication requirements of various parallel architectures and cache coherence mechanisms.
8	**Brief Contents (module wise)**	**Module I:** A Baseline NoC Architecture, MICRO-Architectural Exploration, ViChaR: A Dynamic Virtual Channel Regulator for NoC Routers, Importance of Buffer Size and Organization **Module II:** RoCo: The Row–Column Decoupled Router – A Gracefully Degrading and Energy-Efficient Modular Router Architecture for On-Chip Networks Introduction and Motivation Related Work in Partitioned Router Architectures, Decoupled Router, Row-Column Switch, Blocking Delay, Concurrency Control for High-Contention Environments, Flexible and Reusable On-Chip Communication, Fault-Tolerance Through Hardware Recycling. **Module III:** Exploring FaultoTolerant Network-on-Chip Architectures, Simulation Platform Preliminaries, Handling Link Soft Faults, Flit-Based HBH Retransmission Scheme , Deadlock Recovery , Handling Soft Errors in Intra-Router Logic, Virtual Channel Arbiter Errors, Routing Computation Unit Errors, Switch Allocator Errors, Crossbar Errors, Retransmission Buffer Errors, Handshaking Signal Errors , Handling Hard Faults, Proximity-Aware (PA) Fault-Tolerant Routing Algorithm, Extension of PA Routing for Hot-Spot Avoidance ,Service-Oriented Networking (SON),SON – Direction Lookup Table (DLT) and Service Information Provider (SIP). The Impact of process variation on NoC Architecture.
9	**Contents for lab (If applicable)**	NA
10	**List of text books/references**	1. W. J. Dally and B. Towles, “Principles and Practices of Interconnection Networks,” Morgan Kauffman Publishers, 2004. 2. Duato, S. Yalamanchili, L. Ni, “Interconnection Networks: An Engineering Approach,” Morgan Kauffman Publishers, 2002.

1	**Code of the subject**	BCCS-9705
2	**Title of the subject**	Trustworthy Systems Design
3	**Any prerequisite**	NO
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. PinkuRanjan
6	**Will this course require visiting faculty**	**NO**
7	**Learning Objectives of the subject (in about 50 words)**	➢ This course provides an in-depth introduction to a range of developments for the design of secure and trustworthy computer hardware. ➢ Analyze and use methods for cryptography and reflect about limits and applicability of methods ➢ Students will learn that how the security aspects of software development are embedded into the system to be developed. It includes secure architecture design, secure coding, secure deployment and secure software development methodologies.
8	**Brief Contents (module wise)**	➢ Topics covered include physical and invasive attack models, SCA attacks, physical unclonable functions, hardware-based random number generators, watermarking of intellectual property (IP) blocks, FPGA security, passive and active metering for piracy prevention, and hardware Trojan detection and isolation. ➢ Digital Signatures: Definitions and Applications, Lamport and Merkle Schemes. Overview of Signatures Based on Discrete-Log Certificates and Trust Management., SSL/TLS and Ipsec, Privacy Mechanisms ➢ Requirements Engineering: Availability, Authenticity, Confidentiality, Efficiency, Integrity, Maintainability, Portability, Reliability, Requirements Engineering, Trustworthiness, Threat Analysis and Risk Management ➢ Secure Deployment: Secure Default Configuration, Product Life Cycle, Automated Deployment Process, Secure Target Environment, Secure Delivery of Code, Trusted Origin, Code Signing, Least Privilege Permissions, ITIL Release and Deployment Management
9	**Contents for lab (If applicable)**	NO
10	**List of text books/references**	1.M. Tehranipoor and C. Wang, *Introduction to Hardware Security and Trust*, Springer, 2012. 2.William Stalling, Cryptography and network security: principles and practice, Prentice Hall (2013) 3. Threat Modelling: Designing for Security by Adam Shostack, John Wiley and Sons Inc, (2014). 4. Mano Paul ,7 Qualities of Highly secure Software Taylor and Francis, CRC Press (2012) 5.Gary McGraw ,Software Security: Building Security, Addison-Wesley (2006)

1	**Code of the subject**	BCCS-9706
2	**Title of the subject**	Neurocomputing Architectures/High Performance Computing
3	**Any prerequisite**	NO
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Pinku Ranjan
6	**Will this course require visiting faculty**	NO
7	**Learning Objectives of the subject (in about 50 words)**	➢ To be familiar with the various architectures and Techniques of KnowledgeBased Neural Computing. ➢ To learn the methods for extracting rules from recurrent neural networks. ➢ To apply Data mining Techniques for Information Extraction from Neural Networks. ➢ To develop Hybrid Intelligent Systems.
8	**Brief Contents (module wise)**	➢ Basic concepts of Neuro-Computing: Artificial Neural Network (ANN) and their biological roots and motivations, Mathematical Models of Neurons, ANN architecture, Learning rules, Learning Paradigms: Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms-perceptions, Training rules, Delta, Back Propagation Algorithm, Multilayer Perceptron Model, Applications of Artificial Neural Networks, Competitive learning networks, Kohonenself organizing networks, Hebbian learning; Hopfield Networks, Associative Memories, The boltzman machine; Neurocomputing: Introduction to neural networks, threshold logic Models of neurocomputing: Perceptron,.Adaline, Multi-layer perceptron, backpropagation learning, RBF network, Hopfield networks, ART –I and II, SOFM. Applications in pattern recognition and image processing. Evolutionary computing: Introduction to Evolutionary Computation: Genetic algorithms, Genetic programming, Evolutionary strategies, Evolutionary programming. Genetic algorithms – Chromosome representation, encoding, decoding, Genetic operators: Selection, Crossover, Mutation, Elitism, Schema Theorem, EGA, Convergence theorem, real-coded GA, Ordered GA, Steady-state GA, Multi-objective evolutionary algorithms, applications in search and optimization. Recent advances in Evolutionary Computing (Particle Swarm Optimization, Ant Colony Optimization). Hybridizations: Different types of integrations, merits. Neuron-fuzzy, Neuro-GA, FuzzyGA, Neuro-fuzzy-GA
9	**Contents for lab (If applicable)**	NO
10	**List of text books/references**	1. Jang, Sun, Mizutani, Neuro-Fuzzy and Soft computing, Pearson. 2. Haykin, Neural networks: a comprehensive foundation, Pearson. 3. J. M. Zurada, Introduction to Artificial Neural Systems, West Publishing Co., St. Paul, Minnesota, 1992. 4. J. Hertz, A. Krogh, and R. G. Palmer, Introduction to the Theory of Neural Computation, Addison Wesley, California, 1991. 5.D.E. Goldberg, Genetic algorithms in search, optimization and machine learning, Addison Wesley, 1989.

1	**Code of the subject**	BCCS-9707
2	**Title of the subject**	Advanced Compiler Design
3	**Any prerequisite**	Basic course on Theory of Computation, basic understanding of compiler concepts
4	**L-T-P**	3-0-0
5	**Name of the proposer**	Dr. Santosh Singh Rathore
6	**Will this course require visiting faculty**	Yes
7	**Learning Objectives of the subject (in about 50 words)**	• To understand the theory and practice of compilation, in particular, the lexical analysis, syntax, and semantic analysis, code generation and optimization phases of compilation. • To exemplify and compare various function of parser along with its types for design of compiler.
8	**Brief Contents (module wise)**	**Module I:**The structure of Compiler – Lexical analysis, Syntax analysis, LR parsers, Intermediate code generation, Syntax Directed Definitions, Evaluation orders for syntax directed definitions, Object code generation, Issues in code generation, Design of code generator, Register allocation andassignment, Optimal code generation for expressions. **Module II:** Code optimization: Basic blocks and flow graphs, Optimization of basic blocks, Principal sources of optimizations, Partial redundancy elimination, Peephole optimizations, Parallelizing compiler basic concepts and examples, Iteration spaces, Affine array indexes, Data reuse, Arraydata dependence. **Module III:** Advance topics in compiler design: Symbol table management, Type Inference, Intermediate Language Selection, Run-Time Support, optimizations, Interprocedural analysis, Garbage Collection, Dynamic (JIT) compilation, Program Synthesis, loop transformation, loop parallelization **Module IV:** Multi-level intermediate representations. Principles of code generation, stack organisation and call sequences, local common subexpression elimination, DAGs, lowering **Module V:**Abstract interpretation, Worst-case execution time analysis, Space-optimal scheduling for trees
9	**Contents for lab (If applicable)**	None
10	**List of text books/references**	1. Alfred V. Aho, Monica S.Lam, Ravi Sethi, Jeffrey D.Ullman, "Compilers : Principles, Techniques and Tools", Second Edition, Pearson Education, 2008. 2. Randy Allen, Ken Kennedy, "Optimizing Compilers for Modern Architectures: A Dependence-based Approach", Morgan Kaufmann Publishers, 2002. 3. Steven S. Muchnick, "Advanced Compiler Design and Implementation", Morgan Kaufmann Publishers - Elsevier Science, India, Indian Reprint 2003. 4. Keith D Cooper and Linda Torczon, "Engineering a Compiler", Morgan Kaufmann Publishers Elsevier Science, 2004. 5. V. Raghavan, "Principles of Compiler Design", Tata McGrawHill Education Publishers, 2010.

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