CURRICULUM AND SYLLABI

B. Tech.

in

COMPUTER SCIENCE AND ENGINEERING

COURSES

(I to VIII Semesters)

(Applicable to 2017 admission onwards)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
CALICUT - 673601
KERALA, INDIA

The Programme Educational Objectives (PEOs) of B. Tech in Computer Science and Engineering

Programme Educational Objectives (PEOs)	
PEO1	Graduates shall have sound knowledge regarding the fundamental principles and techniques in the discipline of Computer Science and Engineering.
PEO2	Graduates shall have the ability to specify, design, develop and maintain reliable and efficient software.
PEO3	Graduates shall have the necessary communication and management skills and ethical values to become competent professionals.

The Programme Outcomes (POs) of
B. Tech in Computer Science and Engineering

Programme Outcomes (POs)	
PO1 (Engineering Knowledge)	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2 (Problem Analysis)	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3 (Design/Development of Solutions)	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4 (Conduct Investigations of Complex Problems)	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5 (Modern Tool Usage)	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6 (The Engineer and Society)	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7 (Environment and Sustainability)	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8 (Ethics)	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9 (Individual and Team Work)	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10 (Communication)	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11 (Project Management and Finance)	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12 (Life-Long Learning)	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)	
At the end of the programme, the students will be able to:	
PSO 1 **(Analysis of Computational Problems and Design of Algorithmic Solutions)**	Analyze computational problems and design effective and efficient algorithmic solutions
PSO2 **(Software Implementation)**	Write effective code for implementing algorithmic solutions and use available software tools for the design of efficient software solutions.

CURRICULUM

The total credits for completing the B. Tech. programme in Computer Science and Engineering is 160.

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES

The structure of B.Tech. programmes shall have the following Course categories :

Sl. No.	Course Category	Number of Courses	Minimum Credits
1.	Mathematics (MA)	4	12
2.	Science (BS)	5	10
3.	Humanities (HL)	3	9
4.	Basic Engineering (BE)	6	15
5.	Other Courses (OT)	4	6
6.	Professional Core (PC)	18	70
7.	Departmental Electives (DE)	9	32
8.	Open Electives (OE)	2	6
	TOTAL	51	160

COURSE REQUIREMENTS

1. MATHEMATICS

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	MA1001D	Mathematics I	3	1	0	3
2.	MA1002D	Mathematics II	3	1	0	3
3.	MA2001D	Mathematics III	3	1	0	3
4.	MA2003D	Mathematics IV	3	1	0	3
		Total	12	4	0	12

2. SCIENCE

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	PH1001D	Physics	3	0	0	3
2.	PH1091D	Physics Lab	0	0	2	1
3.	CY1001D	Chemistry	3	0	0	3
4.	CY1094D	Chemistry Lab	0	0	2	1
5.	BT1001D	Introduction to Life Science	2	0	0	2
		Total	8	0	4	10

3. HUMANITIES

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	MS1001D	Professional Communication	3	0	0	3
2.	MS3001D	Engineering Economics	3	0	0	3
3.	ME3104D	Principles of Management	3	0	0	3
		Total	9	0	0	9

4. BASIC ENGINEERING

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	ZZ1001D	Engineering Mechanics	3	0	0	3
2.	ZZ1003D	Basic Electrical Sciences	3	0	0	3
3.	ZZ1002D	Engineering Graphics	1	0	3	3
4.	ZZ1004D	Computer Programming	2	0	0	2
5.	ZZ1091D	Workshop I	0	0	3	2
6.	ZZ1092D	Workshop II	0	0	3	2
		Total	9	0	9	15

5. OTHER COURSES (OT)

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	ZZ1093D	Physical Education	0	0	2	1
2.	ZZ1094D	Value Education	0	0	2	1
3.	ZZ1095D	NSS	0	0	2	1
4.	CS2007D	Environmental Studies	3	0	0	3
		Total	3	0	6	6

6. PROFESSIONAL CORE

Sl.No.	Course Code	Course Title	Pre requisites	L	T	P	Credits
1	CS2001D	Logic Design	NIL	4	0	0	4
2	CS2002D	Program Design	ZZ1004D	4	0	0	4
3	CS2006D	Discrete Structures	NIL	4	0	0	4
4	CS2091D	Logic Design Laboratory	NIL	0	0	3	2
5	CS2092D	Programming Laboratory	NIL	1	0	3	3
6	CS2004D	Computer Organization	CS2001D	4	0	0	4
7	CS2005D	Data Structures and Algorithms	CS2002D, CS2006D	4	0	0	4
8	CS2093D	Hardware Laboratory	NIL	2	0	2	3
9	CS2094D	Data Structures Laboratory	CS2002D, CS2006D	1	0	3	3
10	CS3001D	Theory of Computation	NIL	4	0	0	4
11	CS3002D	Database Management Systems	NIL	3	0	2	4
12	CS3003D	Operating Systems	NIL	3	0	2	4
13	CS3004D	Software Engineering	CS2002D, CS2006D	3	0	2	4
14	CS3005D	Compiler Design	NIL	3	0	2	4
15	CS3006D	Computer Networks	CS2005D	3	0	2	4
16	CS4023D	Artificial Intelligence	NIL	3	0	2	4
17	CS4098D	Project: Part 1	NIL	0	0	6	3
18	CS4099D	Project: Part 2	CS4098D	0	0	16	8
			Total	46	0	45	70

7A. DEPARTMENT LABORATORY ELECTIVES

Sl. No.	Course Code	Course Title	Pre requisites	L	T	P	Credits
1.	CS3091D	Compiler Laboratory	NIL	1	0	3	3
2.	CS3092D	Operating Systems Laboratory	NIL	1	0	3	3
3.	CS3093D	Networks Laboratory	NIL	1	0	3	3
4.	CS3094D	Systems Programming Laboratory	NIL	1	0	3	3
5.	CS3095D	Database Management Systems Laboratory	NIL	1	0	3	3
6.	CS4090D	Computer Security Laboratory	NIL	1	0	3	3
7.	CS4091D	Data Analytics Laboratory	NIL	1	0	3	3
8.	CS4092D	Machine Learning Laboratory	NIL	1	0	3	3
9.	CS4093D	Image Processing Laboratory	NIL	1	0	3	3
10.	CS4094D	Advanced Computer Networks Laboratory	NIL	1	0	3	3
11.	CS4096D	Software Engineering Laboratory	NIL	1	0	3	3
12.	CS4097D	Object Oriented Systems Laboratory	NIL	1	0	3	3
13	CS4088D	Advanced Hardware Laboratory	NIL	1	0	3	3

7B. DEPARTMENT ELECTIVES

Sl. No.	Course Code	Course Title	Pre requisites	L	T	P	Credits
1.	CS4021D	Number Theory and Cryptography	NIL	3	0	2	4
2.	CS4022D	Principles of Programming Languages	NIL	3	0	2	4
3.	CS4024D	Information Theory	NIL	3	0	0	3
4.	CS4025D	Randomized algorithms	NIL	3	0	2	4

5.	CS4026D	Combinatorial Algorithms	NIL	3	0	2	4
6.	CS4027D	Topics in Algorithms	NIL	3	0	2	4
7.	CS4028D	Quantum Computation	NIL	3	0	0	3
8.	CS4029D	Topics in Complexity	NIL	3	0	0	3
9.	CS4030D	Computational Complexity	NIL	4	0	0	4
10.	CS4031D	Computational Algebra	NIL	3	0	2	4
11.	CS4032D	Computer Architecture	NIL	3	0	2	4
12.	CS4033D	Distributed Computing	NIL	3	0	2	4
13.	CS4034D	Middleware Technologies	NIL	3	0	2	4
14.	CS4035D	Computer Security	CS4021D	3	0	2	4
15.	CS4036D	Advanced Database Management Systems	NIL	3	0	2	4
16.	CS4037D	Cloud Computing	NIL	3	0	2	4
17.	CS4038D	Data Mining	CS3002D	3	0	2	4
18.	CS4039D	Multi Agent Systems	NIL	3	0	2	4
19.	CS4040D	Bioinformatics	NIL	3	0	2	4
20.	CS4041D	Natural Language Processing	CS2005D	3	0	2	4
21.	CS4042D	Web Programming	NIL	3	0	2	4
22.	CS4043D	Image Processing	NIL	3	0	2	4
23.	CS4044D	Machine Learning	NIL	3	0	2	4
24.	CS4045D	Medical Image processing	NIL	3	0	2	4
25.	CS4046D	Computer Vision	NIL	3	0	2	4

26.	CS4047D	Computer Graphics	NIL	3	0	2	4
27.	CS4048D	Mathematical Foundations of Machine Learning	NIL	3	0	0	3
28.	CS4049D	Advanced Computer Networks	NIL	3	0	2	4
29.	CS4050D	Design and Analysis of Algorithms	CS2005D	3	0	2	4
30.	CS4051D	Coding Theory	NIL	3	0	0	3
31.	CS4052D	Logic for Computer Science	NIL	3	0	2	4
32.	CS4053D	Topics in Logic	NIL	3	0	0	3
33.	CS4054D	Parameterized Algorithms	NIL	3	0	2	4
34.	CS4055D	Parameterized Complexity Theory	NIL	3	0	0	3
35.	CS4056D	Introduction to High Performance Computing	NIL	3	0	2	4
36.	CS4057D	Embedded Systems	NIL	3	0	2	4
37.	CS4058D	Computational Geometry	NIL	3	0	2	4
38.	CS4059D	Topics in Computational Geometry	NIL	3	0	0	3
39.	CS4060D	Introduction to Data Science	NIL	3	0	2	4
40.	CS4061D	Topics in Data Analytics	NIL	3	0	2	4
41.	CS4062D	Introduction to Information Security	NIL	3	0	0	3
42.	CS4063D	Topics in Cryptography	NIL	3	0	2	4
43.	CS4064D	Program Analysis	NIL	3	0	2	4

44.	CS4065D	Formal Semantics	NIL	3	0	2	4
45.	CS4066D	Algorithmic Decision Making	NIL	3	0	2	4
46.	CS4067D	Foundations of Programming	NIL	3	0	2	4
47.	CS4068D	DNA Computing Models	NIL	3	0	0	3
48.	CS4069D	Hashing Techniques for Big Data	NIL	3	0	0	3
49.	CS4070D	Topics in Computer Networks	NIL	3	0	0	3
50.	CS4071D	Network Analysis in Bioinformatics	NIL	3	0	0	3
51.	CS4089D	Term Paper	NIL	0	0	8	3
52.	CS3007D	Object Oriented Systems	NIL	3	0	2	4
53.	CS4072D	Advanced Programming and Data Structures for Engineers	NIL	3	0	0	3
54.	CS4073D	Computing Systems for Engineers	NIL	3	0	0	3
55.	MA6301	Real Analysis	NIL	4	0	0	4
56.	MA6302	Linear Algebra	NIL	4	0	0	4
57.	MA6323	Graph Theory	NIL	3	0	0	3
58.	MA6324	Abstract Algebra	NIL	4	0	0	4
59.	MA7365	Multivariable Calculus	NIL	3	0	0	3
60.	MA7369	Stochastic Processes	NIL	3	0	0	3

8. OPEN ELECTIVES

Two open elective courses to be credited from a pool of open electives during the third / fourth year.

Programme Structure

Semester I

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	MA1001D	Mathematics I	3	1	0	3	MA
2.	PH1001D/ CY1001D	Physics/Chemistry	3	0	0	3	BS
3.	MS1001D/ ZZ1003D	Professional Communication/ Basic Electrical Sciences	3	0	0	3	HL/BE
4.	ZZ1001D/ ZZ1002D	Engineering Mechanics/ Engineering Graphics	3/2	0	0/2	3	BE
5.	ZZ1004D/ BT1001D	Computer Programming / Introduction to Life Science	2	0	0	2	BE/BS
6.	PH1091D/ CY1094D	Physics Lab/ Chemistry Lab	0	0	2	1	BS
7.	ZZ1091D/ ZZ1092D	Workshop I/Workshop II	0	0	3	2	BE
8.	ZZ1093D/ ZZ1094D/ ZZ1095D	Physical Education /Value Education/ NSS	-	-	-	3*	OT
	Total Credits		14/13	1	5/7	17+3*	

*Note: Three courses of 1 credit each has to be credited within the first four semesters.

Semester II

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	MA1002D	Mathematics II	3	1	0	3	MA
2.	CY1001D/ PH1001D	Chemistry/ Physics	3	0	0	3	BS
3.	ZZ1003D/ MS1001D	Basic Electrical Sciences/ Professional Communication	3	0	0	3	BE/HL
4.	ZZ1002D/ ZZ1001D	Engineering Graphics/ Engineering Mechanics	2/3	0	2/0	3	BE
5.	BT1001D/ ZZ1004D	Introduction to Life Science./ Computer Programming	2	0	0	2	BS/BE
6.	CY1094D/ PH1091D	Chemistry Lab / Physics Lab	0	0	2	1	BS
7.	ZZ1092D/ ZZ1091D	Workshop II/ Workshop I	0	0	3	2	BE
	Total Credits		13/ 14	1	7/5	17	

Semester III

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	MA2001D	Mathematics III	3	1	0	3	MA
2.	CS2001D	Logic Design	4	0	0	4	PC
3.	CS2002D	Program Design	4	0	0	4	PC
4.	CS2006D	Discrete Structures	4	0	0	4	PC
5.	CS2091D	Logic Design Laboratory	0	0	3	2	PC
6.	CS2092D	Programming Laboratory	1	0	3	3	PC
	Total Credits		16	1	6	20	

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	MA2003D	Mathematics IV	3	1	0	3	MA
2.	CS2007D	Environmental Studies	3	0	0	3	OT
3.	CS2004D	Computer Organization	4	0	0	4	PC
4.	CS2005D	Data Structures and Algorithms	4	0	0	4	PC
5.	CS2093D	Hardware Laboratory	2	0	2	3	PC
6.	CS2094D	Data Structures Laboratory	1	0	3	3	PC
	Total Credits		17	1	5	20	

Semester V

Sl. No	Course Code	Course Title	L	T	P	Credits	Category
1.	CS3001D	Theory of Computation	4	0	0	4	PC
2.	CS3002D	Database Management Systems	3	0	2	4	PC
3.	CS3003D	Operating Systems	3	0	2	4	PC
4.	MS3001D/ ME3104D	Engineering Economics / Principles of Management	3	0	0	3	HL
5		Elective I				3/4	DE
6.		Laboratory Elective I	1	0	3	3	DE
	Total Credits					21-22	

Semester VI

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	CS3004D	Software Engineering	3	0	2	4	PC
2.	CS3005D	Compiler Design	3	0	2	4	PC
3.	CS3006D	Computer Networks	3	0	2	4	PC
4.	ME3104D/ MS3001D	Principles of Management / Engineering Economics	3	0	0	3	HL
5.		Elective II				3/4	DE
6.		Laboratory Elective II	1	0	3	3	DE
	Total Credits					21-22	

Semester VII

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	CS4098D	Project: Part 1	0	0	6	3	PC
2.	CS4023D	Artificial Intelligence	3	0	2	4	PC
3.		Elective III				3	OE
4.		Elective IV				4	DE
5.		Elective V				4	DE
6.		Elective VI				4	DE
	Total Credits					22	

Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	Credits	Category
1.	CS4099D	Project: Part 2	0	0	16	8	PC
2.		Elective VII	3	0	0	3	OE
3.		Elective VIII				4	DE
4.		Elective IX				4	DE
	Total Credits					19	

Notes:

1. Since the credits for elective courses may vary, the total credits acquired in a semester can vary. However a student is required to complete all core courses and also the minimum number of elective courses stipulated in the curriculum under each category. **The total credits acquired must be at least 160 for the award of the B.Tech degree.**
2. Elective courses may be credited from the list of elective courses and laboratory elective courses. Laboratory electives will be treated as normal elective courses and hence may be credited as elective courses. However as laboratory electives, students are required to credit courses only from the list of courses specifically mentioned in the curriculum as laboratory electives. Two open electives may be credited in any elective slots in the curriculum.
3. Every student must credit two open elective courses from the open elective pool offered by the institute. If a student has opted for 4 credit Open Elective (OE) courses, he/she may be permitted to credit the corresponding number of 3 credit Department Elective (DE) courses.
4. A student who wishes to take up the final semester project work outside the institute may credit up to one extra elective course in the earlier semesters and may register only for Project: Part 2 in Semester 8.

MA1001D MATHEMATICS I

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Module 1: (13 hours)

Real valued function of real variable: Limit, Continuity, Differentiability, Local maxima and local minima, Curve sketching, Mean value theorems, Higher order derivatives, Taylor's theorem, Integration, Area under the curve, Improper integrals.

Function of several variables: Limit, Continuity, Partial derivatives, Partial differentiation of composite functions, Differentiation under the integral sign, Local maxima and local minima, Saddle point, Taylor's theorem, Hessian, Method of Lagrange multipliers.

Module 2: (13 hours)

Numerical sequences, Cauchy sequence, Convergence, Numerical series, Convergence, Tests for convergence, Absolute convergence, Sequence and series of functions, point-wise and uniform convergence, Power series, Radius of convergence, Taylor series.

Double integral, Triple integral, Change of variables, Jacobian, Polar coordinates, Applications of multiple integrals

Module 3: (13 hours)

Parameterised curves in space, Arc length, Tangent and normal vectors, Curvature and torsion, Line integral, Gradient, Directional derivatives, Tangent plane and normal vector, Vector field, Divergence, Curl, Related identities, Scalar potential, Parameterised surface, Surface integral, Applications of surface integral, Integral theorems: Green's Theorem, Stokes' theorem, Gauss' divergence theorem, Applications of vector integrals.

References:

1. H. Anton, I. Bivensand S. Davis, Calculus, 10th edition, New York: John Wiley & Sons, 2015.
2. G. B. Thomas, M.D. Weirand J. Hass, Thomas' Calculus, 12th edition, New Delhi, India: Pearson Education, 2015.
3. E. Kreyszig, Advanced Engineering Mathematics, 10th edition, New York: John Wiley & Sons, 2015.
4. Apostol, Calculus Vol. 1, 1st ed. New Delhi: Wiley, 2014.

MA1002D MATHEMATICS II

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Module 1: (16 hours)

System of Linear equations, Gauss elimination, Solution by LU decomposition, Determinant, Rank of a matrix, Linear independence, Consistency of linear system, General form of solution.

Vector spaces, Subspaces, Basis and dimension, Linear transformation, Rank-nullity theorem, Inner-product, Orthogonal set, Gram-Schmidt orthogonalisation, Matrix representation of linear transformation, Basis changing rule.

Types of matrices and their properties, Eigenvalue, Eigenvector, Eigenvalue problems, Cayley-Hamiltonian theorem and its applications, Similarity of matrices, Diagonalisation, Quadratic form, Reduction to canonical form.

Module 2: (13 hours)

Ordinary Differential Equations (ODE): Formation of ODE, Existence and uniqueness solution of first order ODE using examples, Methods of solutions of first order ODE, Applications of first order ODE.

Linear ODE: Homogenous equations, Fundamental system of solutions, Wronskian, Solution of second order non-homogeneous ODE with constant coefficients: Method of variation of parameters, Method of undetermined coefficients, Euler-Cauchy equations, Applications to engineering problems, System of linear ODEs with constant coefficients.

Module 3: (10 hours)

Gamma function, Beta function: Properties and evaluation of integrals.

Laplace transform, Necessary condition for existence, General properties, Inverse Laplace transform, Transforms of derivatives and integrals, Differentiation and Integration of transform, Unit-step function, Shifting theorems, Transforms of periodic functions, Convolution, Solution of differential equations and integral equations using Laplace transform.

References:

1. E. Kreyszig, Advanced Engineering Mathematics, 10th edition, New Delhi, India: Wiley, 2015.
2. G. Strang, Introduction to Linear Algebra, Wellesley MA: Cambridge Press, 2016.
3. R. P. Agarwal and D. O 'Regan, An Introduction to Ordinary Differential Equations, New York: Springer, 2008.
4. V. I. Arnold, Ordinary Differential Equations, New York: Springer, 2006.
5. P. Dyke, An Introduction to Laplace Transforms and Fourier Series, New York: Springer,2014.

PH1001D PHYSICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (12 hours)

Particle nature of radiation – Photoelectric effect, Compton effect, Wave nature of matter – matter waves, wave packets description, phase and group velocity, uncertainty principle. Formulation of Schrödinger equation, physical meaning of wave function, expectation values, time-independent Schrödinger equation, quantization of energy for bound particles. Application of time-independent Schrödinger equation to free particle, infinite well, finite well, barrier potential, tunneling.

Module 2: (14 hours)

Simple Harmonic Oscillator, two-dimensional square box, the scanning tunneling microscope. Wave function for two or more particles, indistinguishable particles, symmetry and anti-symmetry under exchange of particles, Pauli's exclusion principle, electronic configurations of atoms. Quantum model of a solid – periodicity of potential and bands, E – k diagram, effective mass, band gap.

Module 3: (13 hours)

Microstates and macrostates of a system, equal probability hypothesis, Boltzman factor and distribution, ideal gas, equipartition of energy, Maxwell speed distribution, average speed, RMS speed, Quantum distributions - Bosons and Fermions, Bose-Einstein and Fermi-Dirac distribution, applications.

References:

1. Kenneth Krane, Modern Physics, 2nd Ed., Wiley (2009)
2. Arthur Beiser, Concepts of Modern Physics, 6th Ed., Tata Mc Graw –Hill Publication (2009)
3. Robert Eisberg and Robert Resnick, Quantum Physics of atoms, Molecules, Solids, Nuclei and Particle, 2nd Ed., John Wiley (2006)
4. David Halliday, Robert Resnick and Jearl Walker, Fundamentals of Physics, 6th Ed., Wiley (2004)

CY1001D CHEMISTRY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (14 hours)

Spectroscopy – General Principles, Infrared, group frequencies, Electronic spectroscopy of conjugated molecules, Woodward-Fieser Rule.

Chromatography – Retention and Separation factors, Theoretical plates, Instrumentation and uses of Gas Chromatography and High Performance Liquid Chromatography

Thermal analysis – Thermogravimetry, Differential Scanning Calorimetry and Differential Thermal Analysis

Module 2: (12 hours)

Electrochemical corrosion – Mechanisms, control and prevention.

Cyclic voltammetry, Switching potentials, Cathodic and anodic peak currents Potentiometry, Fuel cells – Types and applications

Liquid crystals – Phase types, uses in displays and thermography.

Module 3: (13 hours)

Catalysis – Homogeneous and heterogeneous catalysis, Organometallic compounds, 18-electron rule, Oxidative addition, Reductive elimination, insertion and Elimination reactions, Wilkinson's catalyst in alkene hydrogenation, Zeigler-Natta catalysis in polymerization of olefins.

Enzyme catalysis – Mechanisms, significance of Michaelis – Menten constant, Turnover number, Co-enzymes and cofactors

References:

1. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th edition, Tata McGraw Hill, New Delhi, 2010.
2. D. A. Skoog and D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, Brooks Cole, Florence, 2004.
3. H. H. Williard, L. L. Merrit, J. A. Dean and F. A. Settle, *Instrumental Methods of Analysis*, Wadsworth Publishing Company, Belmont, California, 1986.
4. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry,* Vishal Publishing, New Delhi, 2000.
5. J. E. Huheey, E.A. Keiter and R.L. Keiter, *Inorganic Chemistry, Principles of Structure and Reactivity*, 4th Ed, Harper Collins College Publishers, New York, 1993.
6. C. Elschenbroich, *Organometallics*, 3rd edition, Wiley-VCH Verlag GmbH, Weinheim, 2006.

MS1001D PROFESSIONAL COMMUNICATION

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (12 hours)

Role and importance of verbal communication, Everyday active vocabulary, Common words used in transitions, enhancing vocabulary, affixes and changes in pronunciation and grammatical functions, words often confused in pronunciation and usage. Passage comprehension- skimming, scanning techniques, note making, note taking and summarizing. Deciphering meaning from contexts. Two types of meaning- literal and contextual. Constructive criticism of speeches and explanations.

Module 2: (15 hours)

Fundamental grammar, Simple structures, passivizing the active sentences, reported speech, the judicious use of tenses and moods of verbs, forming questions and conversion from questions to statements and vice versa, forming open –ended and close- ended questions. Words and style used for formal and informal communication. Practice converting informal language to formal, the diction and the style of writing. Dealing with the nuances of ambiguous constructions in language. Learning authoritative writing skills, polite writing and good netiquette. Writing for internships and scholarships.

Module 3: (12 hours)

Kinesics, Proxemics, Haptics, and other areas of non-verbal communication, fighting communication barriers, positive grooming and activities on the same. Different types of interviews, and presentation- oral, poster, ppt. Organizing ideas for group discussions, the difference between GD and debates.

References:

1. Duck, Steve and David T. Macmahan. *Communication in Everyday Life*. 3rd Ed. Sage, 2017.
2. Quintanilla, Kelly M. and Shawn T. Wahl. *Business and Professional Communication*. Sage, 2016.
3. Gamble, Kawl Teri and Michael W. Gamble. *The Public Speaking Playbook*. Sage, 2015.
4. Tebeaux, Elizabeth and Sam Dragga. *The Essentials of Technical Communication*, 3rd Ed. OUP, 2015
5. Raman, Meenakshi and Sangeetha Sharma. *Technical Communication: Principles and Practice*, OUP, 2015
6. MacLennan, Jennifer. *Readings for Technical Communication*. OUP, 2007.

ZZ1001D ENGINEERING MECHANICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 hours)

Basic Concepts

Introduction: idealizations of mechanics, vector and scalar quantities, equality and equivalence of vectors, laws of mechanics, elements of vector algebra.

Important vector quantities: position vector, moment of a force about a point, moment of a force about an axis, the couple and couple moment, couple moment as a free vector, moment of a couple about a line.

Equivalent force systems: translation of a force to a parallel position, resultant of a force system, simplest resultant of special force systems, distributed force systems, reduction of general force system to a wrench.

Module 2: (13 hours)

Statics

Equations of equilibrium: free-body diagram, free bodies involving interior sections, general equations of equilibrium, problems of equilibrium, static indeterminacy.

Applications of equations of equilibrium: Trusses: solution of simple trusses using method of joints and method of sections; Friction forces: laws of Coulomb friction, simple contact friction problems; Cables and chains.

Properties of surfaces: first moment and centroid of plane area, second moments and product of area for a plane area, transfer theorems, rotation of axes, polar moment of area, principal axes.

Method of virtual work: principles of virtual work for rigid bodies and its applications.

Module 3: (13 hours)

Dynamics

Kinematics of a particle: introduction, general notions, differentiation of a vector with respect to time, velocity and acceleration calculations in rectangular coordinates, velocity and acceleration in terms of path variables and cylindrical coordinates, simple kinematical relations and applications.

Dynamics of a particle: introduction, Newton's law for rectangular coordinates, rectilinear translation, Newton's law for cylindrical coordinates, Newton's law for path variables, energy and momentum methods: introduction, conservative force field, conservation of mechanical energy, alternative form of work-energy equation, impulse and momentum relations, moment-of-momentum equation.

References:

1. I. H. Shames, *Engineering Mechanics—Statics and Dynamics*, 4th Edition, Prentice Hall of India, 1996.
2. F.P. Beer and E.R. Johnston, *Vector Mechanics for Engineers – Statics,* McGraw Hill Book Company, 2000.
3. J.L. Meriam and L.G. Kraige, *Engineering Mechanics – Statics*, John Wiley & Sons, 2002.
4. R.C Hibbler, Engineering Mechanics—Statics and Dynamics, 11th Edition, Pearson, India, 2009

ZZ1002D ENGINEERING GRAPHICS

Pre-requisites: Nil

L	T	P	C
2	0	2	3

Total hours: 52

Module 1: (15 hours)

Introduction; drawing instruments and their uses; lines, lettering and dimensioning; geometrical construction; constructions of plain, diagonal and vernier scales; orthographic projection—first and third angle projections; orthographic projection of points on principal, profile, and auxiliary planes.

Module 2: (17 hours)

Orthographic projection of straight line in simple and oblique positions; application of orthographic projection of line; orthographic projection of planes in simple and oblique position on principal and profile planes; orthographic projection of lines and planes on auxiliary planes.

Module 3: (20 hours)

Orthographic projection of solids in simple and oblique positions on principal and profile planes; orthographic projections of solids in oblique position using auxiliary plane method; orthographic projection of spheres; orthographic projection of solids in section; development of surfaces of solids; method of isometric projection.

References:

1. N. D. Bhatt, Engineering Drawing, 53rd ed. Anand, India: Charotar Publishing House, 2016.
2. Basant Agrawal and C M Agrawal, Engineering Drawing, 2nd ed. New Delhi, India: McGraw Hill Education (India), 2014.

ZZ1003D BASIC ELECTRICAL SCIENCES

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (11 hours)

Analysis of Resistive Circuits:

v-i relationship for Independent Voltage and Current Sources

Solution of resistive circuits with independent sources- Node Voltage and Mesh Current Analysis, Nodal Conductance Matrix and Mesh Resistance Matrix and symmetry properties of these matrices

Source Transformation and Star-Delta / Delta-Star Conversions to reduce resistive networks

Circuit Theorems - Superposition Theorem, Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem.

Magnetic Circuits:

MMF, Magnetic Flux, Reluctance, Energy stored in a Magnetic Field, Solution of Magnetic Circuits.

Two Terminal Element Relationships:

Inductance - Faraday's Law of Electromagnetic Induction, Lenz's Law, Self and Mutual Inductance, Inductances in Series and Parallel, Mutual Flux and Leakage Flux, Coefficient of Coupling, Dot Convention, Cumulative and Differential Connection of Coupled Coils.

Capacitance – Electrostatics, Capacitance, Parallel Plate Capacitor, Capacitors in series and parallel, Energy stored in Electrostatic Field, v-i relationship for Inductance and Capacitance

Module 2: (9 hours)

Single Phase AC Circuits:

Alternating Quantities - Average Value, Effective Value, Form and Peak factors for square, triangle, trapezoidal and sinusoidal waveforms.

Phasor representation of sinusoidal quantities - phase difference, Addition and subtraction of sinusoids, Symbolic Representation: Cartesian, Polar and Exponential forms.

Analysis of a.c circuits - R, RL, RC, RLC circuits using phasor concept, Concept of impedance, admittance, conductance and susceptance.

Power in single phase circuits - instantaneous power, average power, active power, reactive power, apparent power, power factor, complex power, solution of series, parallel and series parallel a.c circuits.

Module 3 (11 hours)

Sensors and Transducers:

principles of piezoelectric, photoelectric, thermoelectric transducers, thermistors, strain gauge, LVDT, etc, Measurement of temperature, pressure, velocity, flow, pH, liquid level, etc.

Basics of Signal Amplification:

(Explanation based on two port models is only envisaged) – voltage gain, current gain and power gain, amplifier saturation, types of amplifiers (voltage, current, transconductance and transresistance amplifiers) and relationship between these amplifier models, frequency response of amplifiers, single time constant networks.

Operational amplifier basics:

Ideal op-amp, inverting, noninverting, summing and difference amplifiers, integrator, differentiator.

Module 4: (8 hours)

Digital Electronics:
Review of number systems and Boolean algebra, Logic Gates and Truth Tables, Simplification of Boolean functions using Karnaugh map (upto 4 variable K-maps), Implementation of Simple combinational circuits (Adder, Code Converters, 7-Segment Drivers, Comparators, Priority Encoders, etc) - MUX-based implementation of combinatorial circuits , Sequential circuits: SR,JK, T and D filpflops, counters and registers using D flip flops, Basics of data converters (at least one ADC and DAC).

References:

1. J.W. Nilsson and S.A. Riedel, *Electric Circuits*, 8th ed., Pearson, 2002
2. K.S. Suresh Kumar, *Electric Circuits & Networks*, Pearson Education, 2009
3. C. A. Desoer and E. S. Kuh, *Basic Circuit Theory*, McGraw Hill, 2009
4. J. A. Edminister, *Electric Circuit Theory*, Schaum's Outline series: 6th ed., McGraw Hill, 2014
5. A. D. Helfrick and W. D. Cooper, *Modern Electronic Instrumentation and Measurement Techniques*, Prentice Hall of India, 2003
6. A. S. Sedra and K. C. Smith, *Microelectronics*, 6thed.,Oxford University Press, 2013
7. C. H. Roth and L. L. Kinney, *Fundamentals of Logic Design*,7thed., Cengage Learning,2014

ZZ1004D COMPUTER PROGRAMMING

Pre-requisites: Nil.

L	T	P	C
2	0	0	2

Total hours: 26

Module 1: (10 hours)

Data Types, Operators and Expressions: Variables and constants - declarations - arithmetic and logical operators – Assignment operator – Input/Output.

Control Flow: Statements and blocks – if-else, switch, while, for and do-while statements – break and continue – goto and labels.

Module 2: (08 hours)

Functions and Program structure: Basics of functions, Parameter passing – scope rules – recursion.

Module 3: (08 hours)

Aggregate data types: Single and multidimensional arrays, structures and unions – Pointers to arrays and structures – passing arrays and pointers as arguments to functions.

References:

1. B.S. Gottfried, *Programming with C (Schaum's Outline Series)*, 2nd ed. McGraw-Hill,1996.
2. B. W. Kernighan and D. M. Ritchie, *The C Programming Language*, 2nd ed. Prentice Hall, 1988.
3. W. Kernighan, *The Practice of Programming*, Addison-Wesley, 1999.

PH1091D PHYSICS LAB

Pre-requisites: Nil

L	T	P	C
0	0	2	1

Total hours: 26

List of Experiments:

1. Magnetic Hysteresis loss - Using CRO
2. Band gap using four probe method
3. Hall effect- determination of carrier density, Hall coefficient and mobility
4. Solar cell characteristics
5. Double refraction – measurement of principle refractive indices.
6. Measurement of N.A & Attenuation
7. Measurement of e/m of electron – Thomson's experiment
8. Determination of Planck's constant
9. Measurement of electron charge – Millikan oil drop experiment
10. Determination of magnetic field along the axis of the coil
11. Newton's rings
12. Laurent's Half shade polarimeter –determination of specific rotatory power
13. Study of P-N junction
14. Study of voltage-current characteristics of a Zener diode.
15. Laser – measurement of angle of divergence & determination of λ using grating
16. Measurement of magnetic susceptibility- Quincke's Method / Gouy's balance.
17. Mapping of magnetic field
18. Temperature measurement by using thermocouple

NOTE: Any 8 experiments have to be done.

References:

1. A.C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press (2003)
2. Avadhanulu, Dani and Pokley, Experiments in Engineering physics, S. Chand & Company ltd (2002).
3. S.L. Gupta and V. Kumar, Practical physics, Pragathi Prakash (2005)

CY1094D CHEMISTRY LAB

Pre-requisites: Nil

L	T	P	C
0	0	2	1

Total hours: 26

List of Experiments:

1. Determination of specific rotation by polarimetry
2. Potentiometric titrations
3. Estimation of ions using complexometry
4. Determination of strength of an acid using pH meter
5. Analysis of organic and inorganic compounds
6. Conductometric titrations using acid or mixture of acids
7. Separation of compounds using chromatography
8. Colorimetric estimations
9. Determine the eutectic temperature and composition of a solid two component system
10. Synthesis of organic/inorganic compounds and their characterizations
11. Determination of molecular weight of polymers

Note: Selected experiments from the above list will be conducted

References:

1. G. H. Jeffery, J. Bassett, J. Mendham and R.C. Denny, *Vogel's Text Book of Quantitative Chemical Analysis*, Longmann Sci tific and Technical, John Wiley, New York,1989.
2. A. I. Vogel, *Elementary Practical Organic Chemistry – Small Scale Preparations*, Pearson India, New Delhi, 2011.
3. A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hannaford and P. W. G. Smith, *Vogel's Text Book of Practical Organic Chemistr*y, Longman and Scientific Technical, New York, 1989.

ZZ1091D WORKSHOP I

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Civil Engineering Workshop: (24 hours)

1. Introduction to Surveying – Linear measurements – Hands on session on Setting out of a small residential building.
2. Introduction to Levelling – Hands on sessions using Dumpy level – Levelling exercise.
3. Introduction to Total Station – Hands on sessions - small exercises.
4. Tests on cement and aggregates: Demonstration of standard consistency, initial and final setting time of cement - Hands on sessions - Compressive strength test on cement mortar cubes and sieve analysis for coarse and fine aggregates.
5. Tests on hardened concrete, brick, timber and steel: Demonstrations on hardness tests (Rockwell hardness), impact tests (Charpy and Izod) on steel specimens-demonstration on properties of timber – Hands on sessions - Compression test on concrete cubes, bricks and tension test on mild steel specimen.
6. Masonry: Hands on sessions - English bond, Flemish bond – wall junction – one brick – one and a half brick - Arch construction.
7. Water supply and sanitation: Study of water supply pipe fittings – tap connections – sanitary fittings
8. Various tests on Driver characteristics – Visual acuity and colour blindness, peripheral vision, depth perception, driver reaction time.

Electrical Engineering Workshop: (15 hours)

1. (a) Familiarization of wiring tools, lighting and wiring accessories, various types of wiring systems.

   (b) Wiring of one lamp controlled by one switch.
2. (a) Study of Electric shock phenomenon, precautions, preventions, Earthing.

   (b) Wiring of one lamp controlled by two SPDT Switches and one 3 pin plug socket independently.
3. (a) Familiarization of various types of Fuses, MCBs, ELCBs, etc.

   (b) Wiring of fluorescent lamp controlled by one switch with ELCB & MCB.
4. (a) Study of estimation and costing of wiring.

   (b) Wiring, control and maintenance of domestic appliances like Mixer machine, Electric Iron, fan, motor, etc.

References:

1. T.P. Kanetkar, S.V. Kulkarni, *Surveying and Levelling - Part1*, Pune Vidyarthi Griha Prakashan, Pune, 1994.
2. B.C. Punmia, *Building Construction*, Laxmi Publications, New Delhi1999.
3. Satheesh Gopi, R. Sathikumar, N. Madh, *Advnaced Surveying*, Pearson Education,2007.
4. M.S. Shetty, *Concrete Technology*, S. Chand & Company, New Delhi,2005.
5. K. B. Raina & S. K. Bhattacharya, *Electrical Design Estimating and costing*, New Age International Publishers, New Delhi, 2005.
6. Khanna, S. K., and Justo, C. E. G., *Highway Engineering*, Nemchand and Bros, Roorkee,2001.
7. Uppal S. L., *Electrical Wiring & Estimating*, Khanna Publishers---5th edition, 2003.
8. John H. Watt, *Terrell Croft American Electricians' Handbook: A Reference Book for the Practical Electrical Man*, 9th ed. McGraw-Hill, 2002.

ZZ1092D WORKSHOP II

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Mechanical Engineering Workshop: (24 hours)

The course is intended to expose the student to various manufacturing processes through hands on training in different sections of Central Workshop. During the course, the student learns the properties and selection of different materials and acquires the skill in using various tools and measuring devices.

1. Carpentry: Study of tools and joints – plaining, chiseling, marking and sawing practice, one typical joint- Tee halving/Mortise and Tenon/ Dovetail
2. Fitting: Study of tools- chipping, filing, cutting, drilling, tapping, about male and female joints, stepped joints. Edge preparation for single V joint.
3. Welding: Study of arc and gas welding, accessories, joint preparation. Welding of a single V joint
4. Smithy: Study of tools. Forging of square or hexagonal prism/chisel/bolt
5. Foundry: Study of tools, sand preparation. Moulding practice using the given pattern.
6. Sheet Metal: Study of tools, selection of different gauge sheets, types of joints. Fabrication of a tray or a funnel
7. Machine Shop: Study of the basic lathe operations. Simple step turning exercise.

Electronics Engineering Workshop: (15 hours)

1. (a) Familiarization of electronic components, colour code, multimeters.

   (b) Bread board assembling-Common emitter amplifier.
2. (a) Study of soldering components, solders, tools, heat sink.

   (b) Bread board assembling-phase shift oscillator.
3. (a) Soldering practice-Common emitter amplifier.

   (b) Soldering practice-Inverting amplifier circuit.
4. (a) Study of estimation and costing of soldering PCB, 3 phase connections.

   (b) PCB wiring and fault Identification of appliances like Electronic Ballast, fan regulator, inverter, UPS, etc.

References:

1. W. A. J. Chapman, Workshop Technology - Parts 1 & 2, 4th ed. New Delhi, India, CBS Publishers & Distributors Pvt. Ltd., 2007.
2. Welding Handbook. 9th ed. Miami, American Welding Society, 2001.
3. J. Anderson, Shop Theory, New Delhi, India, Tata McGraw Hill, 2002.
4. J. H. Douglass, Wood Working with Machines, Illinois, McKnight & McKnight Pub. Co., 1995.
5. W.A. Tuplin, Modern Engineering Workshop Practice, Odhams Press, 1996.
6. P. L. Jain, Principles of Foundry Technology, 5th ed. New Delhi, India, Tata McGraw Hill, 2009.
7. John H. Watt, Terrell Croft, American Electricians' Handbook: A Reference Book for the Practical Electrical Man, 9th ed. McGraw-Hill, 2002.
8. G. Randy Slone, Tab Electronics Guide to Understanding Electricity and Electronics, 2nd ed. McGraw-Hill, 2000.

9. Jerry C Whitaker, The Resource Handbook of Electronics, CRC Press-2001.

ZZ1093D PHYSICAL EDUCATION

Pre-requisites: Nil

L	T	P	C
1	0	1	1

Total hours: 26 (13 L +13 P)

UNIT – I - Introduction, definition, aims & objectives of Physical Education. Health, Physical fitness and wellness. Importance, scope and relevance of Physical Education in NITC curriculum.

UNIT – II - Physical fitness and components. Health related Physical fitness and components. Benefits of exercise – physical and physiological.

UNIT – III - Physical exercise and its principles. Activities for developing physical fitness – walking, jogging, running, weight training, stretching, yogasanas. Athletic injuries and their management. Nutritional balance.

UNIT – IV - Motivation and its importance in sports. Stress, anxiety, tension, aggression in sports. Personality, self-confidence and performance. Team cohesion and leadership in sports.

UNIT – V - Lifestyle diseases and its management, Diabetes and Obesity, Hypertension, Osteoporosis Coronary heart diseases and cholesterol. Backpain, Postural deformities and their remedies.

UNIT – VI. - Olympic Values Education. Event & Crisis management.

References

1. Najeeb, A. M., Atul, M., Sumesh, D. and Akhilesh, E. *Fitness Capsule for university curriculum*, 2015

ZZ1094D VALUE EDUCATION

L	T	P	C
1	0	1	1

Total hours: 39

Unit I (2 hours): **Social Justice** Definition –need-parameters of social justice –factors responsible for social injustice –caste and gender –contributions of social reformers.

Unit II (3 hours)**: Human Rights and Marginalized People** Concept of Human Rights-Principles of human rights-human rights and Indian Constitution-Rights of Women and children-violence against women –Rights of marginalized People-like women, children, dalits, minorities, physically challenged etc.

Unit III (3 hours): **Social Issues and Communal Harmony** Social issues–causes and magnitude-alcoholism, drug addiction, poverty, unemployment etc.-communal harmony-concept-religion and its place in public in public domain-separation of religion from politics-secularism role of civil society.

Unit IV (3 hours): **Media Education and Globalized World Scenario** Mass media-functions-characteristics-need and purpose of media literacy-effects and influence –youth and children-media power-socio cultural and political consequences mass mediated culture-consumerist culture-Globalization-new media –prospects and challenges-Environmental ethics

Unit V (2 hours): **Values and Ethics** Personal values –family values-social values-cultural values-professional values-and overall ethics-duties and responsibilities

Project: 10 hours

References

1. Sharma, B. K. (2010), 'Human Rights Covenants and Indian Law', PHI Learning Pvt. Ltd.
2. Law Commission of India, (1971), 'Indian Penal code', (http://lawcommissionofindia.nic.in/1-50/report42.pdf), accessed on February 14, 2018.
3. Srivastava, S. S. (2017), 'Central Law Agency's Indian Penal Code along with General Principles (IPC)', Central Law Agency.
4. 'Gandhiji on Communal Harmony', (2003), Mani Bhavan Gandhi Sangrahalaya', Mumbai.
5. 'Social Impact of Drug Abuse', UNDCP, ((https://www.unodc.org/pdf/technical_series_1995-03-01_1.pdf, accessed on February 14, 2018).
6. Bryfonski, D. (2012), 'The Global Impact of Social Media', Green Heaven Publications**.**
7. Schmidtz, D. &Willott, E. (2012), 'Environmental Ethics: What Really Matters, What Really Works', Oxford University Press.
8. Ranganathanda, S. (1987), 'Eternal Values for a Changing Society: Education for human excellence', BharatiyaVidyaBhavan.
9. Rokeach, M. (1979), 'Understanding human values: Individual and Societal', The New Free Press.

ZZ1095D NSS

L	T	P	C
0	0	3	1

Total hours: 39

NSS activities have been divided in two major groups. These are Regular NSS Activities and Special Camping programme.

(a) Regular NSS Activity: NSS volunteers undertake various activities in adopted villages and slums for community service. The NSS units organise the regular activities as detailed below:

i) Orientation of NSS volunteers: To get the NSS volunteers acquainted with the basics of NSS programmes, for their orientation through lectures, discussions, field visits, audio-visuals etc.

ii) Campus Work: The NSS volunteers may be involved in the projects undertaken for the benefit of the institution and students concerned. Such projects cover maintenance of public properties, tree plantation, waste management and Swach Bharat activities, conservation of water and energy sources, social audits, awareness programmes on drug-abuse, AIDS, population education, and other projects

iii) Community service will be in adopted villages/urban slums independently or in collaboration with others in this field.

iv) Institutional work: The students may be placed with selected voluntary organisations working for the welfare of women, children, aged and disabled outside the campus.

v) Rural Project: The rural projects generally include the working of NSS volunteers in adopted villages for e-governance and digital literacy, watershed management and wasteland development, rainwater harvesting, agricultural operations, health, nutrition, hygiene, sanitation, mother and child care, gender equality sensitization programmes, family life education, gender justice, development of rural cooperatives, savings drives, construction of rural roads, campaign against social evils etc.

vi) Urban Projects: In addition to rural projects other include adult education, welfare of slum dwellers, work in hospitals, orphanages, destitute home, environment enrichment, population education, drug, AIDS awareness, and income generation,

vii) National Days and Celebrations: The National Service Scheme programmes also include the celebration of National days. The purpose of such a provision is to celebrate such occasions in a befitting manner,

viii) Blood Donation Activities,

ix) Campus farming activities,

x) Activities for social inclusion such as organizing programmes for differently – abled children.

Students shall volunteer and contribute to the activities of the National Service Scheme for a minimum duration of 39 hours for the award of credit.

b) Special Camping Programme: Under this, camps of 7 days’ duration are organised during vacations with some specific projects by involving local communities.

CS2001D LOGIC DESIGN

Prerequisites: NIL

L	T	P	C
4	0	0	4

Total Hours: 52

Module 1: (13 Hours)

Number systems and codes, Boolean algebra: postulates and theorems, constants, variables and functions, switching algebra, Boolean functions and logical operations, Karnaugh map: prime cubes, minimum sum of products and product of sums, Introduction of HDLs and their syntax.

Module 2: (13 Hours)

Quine-McCluskey algorithm, prime implicant chart, cyclic prime implicant chart, Petrick's method, Combinational Logic: introduction, analysis and design of combinational logic circuits, parallel adders and look-ahead adders, comparators, decoders and encoders, code conversion, multiplexers and demultiplexers, parity generators and checkers

Module 3: (13 Hours)

Programmable Logic Devices, ROMs, PALs, PLAs, PLA folding, design for testability. Introduction to sequential circuits, memory elements, latches

Module 4: (13 Hours)

Flip-flops, analysis of sequential circuits, state tables, state diagrams, design of sequential circuits, excitation tables, Mealy and Moore models, registers, shift registers, counters

References:

1. T. L. Floyd and R. P. Jain, *Digital Fundamentals*, 8/e, Pearson Education, 2006.
2. C. H. Roth, Jr., and L. L. Kinney, *Fundamentals of Logic Design*, 6/e, Cengage Learning, 2009.
3. M. M. Mano and M. D. Ciletti, *Digital Design*, 4/e, Pearson Education, 2008.
4. B. J. LaMeres, *Introduction to Logic Circuits & Logic Design with Verilog*, 1/e, Springer, 2017.

CS2002D PROGRAM DESIGN

Prerequisites: ZZ1004D Computer Programming

L	T	P	C
4	0	0	4

Total Hours: 52

Module 1: (13 Hours)

Review of Programming Constructs- Conditional and Iterative constructs, Data types, Control Structures, Functions, Parameter passing- calling conventions, Recursion, Asymptotic notation for complexity analysis.

Module 2: (13 Hours)

Searching - Linear and Binary, Sorting- Insertion and Selection sorting, Divide and conquer, Quick sort, Merge Sort, Heap Sort, External Sorting.

Module 3: (13 Hours)

Pointers and dynamic memory allocation, Abstract Data Types, Lists, Stacks, Queues, Trees, Search Trees and traversal algorithms, Heaps and Priority queues.

Module 4: (13 Hours)

Memory Management, Garbage collection algorithms, Storage allocation for objects with mixed sizes, Buddy systems, Storage compaction.

References:

1. A. V. Aho, J. E. Hopcroft, and J. D. Ullman, *Data Structures and Algorithms*, Addison-Wesley, 1983.
2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms,* 3/e, MIT Press, 2009.
3. E. Horowitz, S. Sahni, and D. Mehta, *Fundamentals of Data Structures in C++*, 2/e, Universities Press, 2008.

CS2006D DISCRETE STRUCTURES

Prerequisites: NIL

L	T	P	C
4	0	0	4

Total Hours: 52

Module 1: (13 Hours)

Combinatorics: Asymptotic analysis of recurrence - solution to recurrences. Graph Theory: Elementary properties - planar graphs - Euler's theorem - Five colour theorem.

Module 2: (13 Hours)

Discrete Probability : Discrete probability spaces, events, random variables, probabilistic method for solving combinatorial problems. Conditional probability, Bayes Theorem. Independent events. Binomial distribution and Geometric distribution. Linearity of expectations, method of conditional expectation, applications to analysis of randomized algorithms. Variance of a random variable. Markov and Chebyshev bounds.

Module 3: (13 Hours)

Algebra: Groups, Lagrange's theorem, Subgroups, Cyclic subgroups, Group Homomorphisms, Homomorphism theorem, Kernel of a homomorphism, Normal subgroups. Rings and Fields, Ring Homomorphisms, Ideals. Division rings, integral domains. Structure of the ring Zn and the unit group Zn*, polynomials over Zp. Order Structures: Equivalence relations, posets, lattices and boolean lattices.

Module 4: (13 Hours)

Logic and Set Theory: Boolean logic, Resolution in propositional logic - introduction to first order logic - set theory - countable and uncountable sets - diagonalization.

References:

1. R. P. Grimaldi, *Discrete and Combinatorial Mathematics: An Applied Introduction*, Addison Wesley, 1998.
2. L. Lovasz, J. Pelikan, and K. Vesztergombi, *Discrete Mathematics*, Springer, 2003.
3. I. M. Copi, *Symbolic logic*, Prentice Hall, 1979

CS2091D LOGIC DESIGN LABORATORY

Prerequisites: NIL

L	T	P	C
0	0	3	2

Total Hours: 39

Practical: (39 Hours)

Design and implementation of the following logic gates and circuits using HDLs

1. AND, OR, NOT, NAND, NOR and XOR
2. Latches and Flip-flops
3. Adders and subtractors
4. Multiplexers and demultiplexers
5. Parity generators, code converters and comparators
6. Counters and Registers

References:

1. B. J. LaMeres, *Introduction to Logic Circuits & Logic Design with Verilog*, 1/e, Springer, 2017.
2. S. Brown and Z. Vranesic, *Fundamentals of Digital Logic with Verilog Design*, McGraw-Hill Higher Education, Har/Cdr edition, 2002.
3. M. M. Mano and M. D. Ciletti, *Digital Design*, 4/e, Pearson Education, 2008.
4. T. L. Floyd and R. P. Jain, *Digital Fundamentals,* 8/e, Pearson Education, 2006.

CS2092D PROGRAMMING LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Review of dynamic memory allocation - use of pointers - review of recursion. File organization.

Practical (39 Hours)

1. Iterative and recursive algorithms
2. Searching: Binary search implementation
3. Sorting: Heap sort, Quick sort and Merge sort implementation
4. Stack and Queue implementation using linked list
5. Arithmetic expression to postfix
6. Postfix to expression tree, tree traversal and evaluation
7. Binary search tree - insert, delete and search.

References:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms,* 3/e, MIT Press, 2009.
2. E. Horowitz, S. Sahni S, and D. Mehta, *Fundamentals of Data Structures in C*++, 2/e, Universities Press, 2008.
3. M. A. Weiss, *Data structures and algorithm analysis*, Addison-Wesley 1992.

CS2004D COMPUTER ORGANIZATION

Prerequisites: CS2001D Logic Design

L	T	P	C
4	0	0	4

Total Hours: 52

Module 1: (13 Hours)

Computer abstraction and technology: basic principles, hardware components, Measuring performance: evaluating, comparing and summarizing performance.
Instructions: operations and operands of the computer hardware, representing instructions, making decision, supporting procedures, character manipulation, styles of addressing, starting a program.

Module 2: (13 Hours)

Computer arithmetic: signed and unsigned numbers, addition and subtraction, logical operations, constructing an ALU, multiplication and division, floating point representation and arithmetic, Parallelism and computer arithmetic.

Module 3: (13 Hours)

The processor: building a data path, simple and multicycle implementations, microprogramming, exceptions, Pipelining, pipeline data path and Control , hazards in pipelined processors

Module 4: (13 Hours)

Memory hierarchy: caches, cache performance, virtual memory, common framework for memory hierarchies

References:

1. D. A. Patterson and J. L. Hennessy, *Computer Organisation and Design: The Hardware/Software Interface*, 5/e, Morgan Kaufmann, 2014.
2. V. P. Heuring and H. F. Jordan, *Computer System Design and Architecture*, Prentice Hall, 2003.

CS2005D DATA STRUCTURES AND ALGORITHMS

Prerequisites: CS2002D Program Design, CS2006D Discrete Structures

L	T	P	C
4	0	0	4

Total Hours: 52

Module 1: (07 Hours)

Review: Time and space complexity analysis, proof of correctness of algorithms, simple data structures and applications, Dictionaries, Hashing. Probabilistic Analysis. Amortized Analysis. Methods and examples.

Module 2: (19 Hours)

Graphs,Trees and Positional trees. Review of Binary Trees and Binary Search Trees. Rotations. Red black Trees, AVL Trees, Splay trees. Mergeable heaps. Fibonacci Heaps. Data structures for disjoint sets - union by rank and path compression

Module 3: (13 hours)

Graph representation- DFS, BFS, minimum spanning tree problem - Kruskal's algorithm - analysis and implementation using disjoint set data structure – Prim's algorithm - Shortest path problem - Dijkstra's algorithm - analysis and implementation of Prim's and Dijkstra's algorithms using priority queues. Bellman Ford, Floyd-Warshall algorithms.

Module 4: (13 Hours)

Randomized Data Structures. Treaps, Skip lists. Randomized primality testing. Distributed Hashing and searching. Persistent Data Structures

References:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms,* 3/e, MIT Press, 2003
2. A. V. Aho, J. D. Ullman, and J. E. Hopcroft, *Data Structures and Algorithms*, Addison Wesley, 1983.
3. D. Kozen, *The Design and Analysis of Algorithms,* Springer, 1991.
4. C. Okasaki, *Purely Functional Data Structures,* Cambridge University press, 1999

CS2093D HARDWARE LABORATORY

Prerequisites: NIL

L	T	P	C
2	0	2	3

Total Hours: 26T+26P

Theory (26 Hours)

Introduction to 8086 Microprocessor; Architecture of 8086, Memory addressing, Assembly Language Programming using 8086, Instruction set of 8086, Data movement Instructions, Arithmetic and logic instructions, Program control instructions, String handling instructions, procedures, recursions, floating point instructions, Basics of SIMD programming.

Memory and I/O interfacing, interfacing with 8255- Programmable peripheral interface, 8279 – programmable keyboard interface, 8254 timer interface - 16550 UART interface - ADC/DAC interfaces. Interrupts, hardware interrupts, Programmable interrupt controller 8259, Interrupt examples. Direct Memory Access, Basic DMA operation, 8257 DMA controller, Bus interface, ISA, VESA, PCI, USB

Introduction to NASM assembler, Sections in NASM, variables declarations, Basic instruction set, Basic I/O operations in NASM, Linux system calls, Interrupts, Linux 0x80h interrupt, Subprograms in NSAM, Arrays and strings, Using C Library functions in NASM, executing NASM programs, Sample programs, Floating point operations, SIMD operations.

Practical (26 Hours)

1. 80X86 Assembly language programming:
   Integer operations,
   Operations on arrays,
   Recursive subroutines,
   String manipulation,
   Floating point operations
   SIMD operations
2. Familiarization of PC hardware and troubleshooting

References:

1. P. Abel, *IBM PC Assembly Language and Programming,* 5/e, Prentice Hall, 2001.
2. B. B. Brey, *Intel Microprocessors: Architecture and Programming,* Prentice Hall, 2008.

CS2094D DATA STRUCTURES LABORATORY

Prerequisites: CS2002D Program Design, CS2006D Discrete Structures

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Review of dynamic memory allocation - use of pointers - review of recursion. File organization.

Practical (39 Hours)

1. Linear time DFS and BFS implementation with adjacency list representation. (3)
2. Kruskal's algorithm implementation in O((n+e)log n) complexity. (3)
3. Prim's algorithm implementation in O((n+e)log n) complexity. (3)
4. Dijkstra's algorithm implementation in O((n+e)log n) complexity. (3)
5. Implementation of BST, rotations, and red black trees. (8)
6. Implementation of splay trees. (6)
7. Implementation of skip lists. (6)
8. Implementation of Random Treaps. (7)

References:

1. T. H. Cormen, C. E. Leiserson, and R. L. Rivest, *Introduction to Algorithms*, PHI, 1998
2. S. Sahni, *Data Structures, Algorithms, and Applications in C++*, McGraw Hill, 1998

CS3001D THEORY OF COMPUTATION

Prerequisites: NIL

L	T	P	C
4	0	0	4

Total Hours: 52

Module 1: (13 Hours)

Basic concepts of Languages, Automata and Grammar. Regular Languages - Regular expression - finite automata equivalence, Myhill Nerode theorem and DFA State Minimization, Pumping Lemma and proof for the existence of non-regular languages.

Module 2: (13 Hours)

Context Free languages, CFL-PDA equivalence, Pumping Lemma and proof for existence of non- Context Free languages, CYK Algorithm, Deterministic CFLs, Chomsky Schutzenberger Theorem.

Module 3: (13 Hours)

Turing Machines: recursive and recursively enumerable languages, Universality of Turing Machine, Church Thesis. Chomsky Hierarchy, Undecidability, Reducibility, Undecidability: Recursive and Recursively enumerable sets.

Module 4: (13 Hours)

Complexity: Time and space complexity classes, hierarchy theorems, reductions and completeness, NP Completeness and PSPACE completeness, examples.

References:

1. M. Sipser, *Introduction to the Theory of Computation*, Thomson, 2001.
2. D. C. Kozen, *Automata and Computability*, Addison Wesley, 1994.
3. J. C. Martin, *Introduction to Languages and the Theory of Computation,* McGraw Hill, 2002.

CS3002D DATABASE MANAGEMENT SYSTEMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T + 26P

Module 1: (10T+8P Hours)

Database System Concepts and architecture, Data Modeling using Entity Relationship (ER) model and Enhanced ER model, Specialization, Generalization, Data Storage and indexing, Single level and multi level indexing, Dynamic Multi level indexing using B Trees and B+ Trees.

Module 2: (10T+8P Hours)

The Relational Model, Relational Database design using ER to relational mapping, Relational algebra and relational calculus, Tuple Relational Calculus, Domain Relational Calculus, SQL.

Module 3: (10T+5P Hours)

Database design theory and methodology, Functional Dependencies and Normalization of relations, Normal Forms, Properties of relational decomposition, Algorithms for relational database schema design.

Module 4: (9T+5P Hours)

Transaction processing concepts, Schedules and serializability, Concurrency control, Two Phase Locking Techniques, Optimistic Concurrency Control, Database recovery concepts and techniques, Introduction to database security.

References:

1. R. Elmasri and S. B. Navathe, *Fundamentals of Database Systems,* 6/e, Pearson Education, 2011.
2. R. Ramakrishnan and J. Gehrke, *Database Management Systems,* 3/e, McGraw Hill, 2003.
3. P. Rob and C. Coronel, *Database Systems- Design, Implementation and Management,* 7/e, Cengage Learning, 2007.

CS3003D OPERATING SYSTEMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (9T+6P Hours)

Review of operating system strategies - resources - processes - threads - objects - operating system organization - design factors - functions and implementation considerations - devices - characteristics - controllers - drivers - device management - approaches - buffering - device drivers - typical scenarios such as serial communications - storage devices etc

Module 2: (10T+8P Hours)

Process management - system view - process address space - process and resource abstraction - process hierarchy - scheduling mechanisms - uniprocessor and multiprocessor scheduling-various strategies - synchronization - interacting & coordinating processes - semaphores - deadlock - prevention - avoidance - detection and recovery

Module 3: (10T+6P Hours)

Memory management - issues - memory allocation - dynamic relocation - various management strategies - virtual memory - paging - issues and algorithms - segmentation - typical implementations of paging & segmentation systems

Module 4: (10T+6P Hours)

File management - files - implementations - storage abstractions - memory mapped files - directories and their implementation - protection and security - policy and mechanism - authentication - authorization - case study of Unix and Linux kernel .Virtual machines – virtual machine monitors – issues in processor, memory and I/O virtualization, hardware support for virtualization.

References:

1. A. Silberschatz, P. B. Galvin, and G. Gagne, *Operating System Principles*, 9/e, John Wiley,2013.
2. W. Stallings, *Operating Systems:Internals and design Principles*, 7/e, Pearson Education, 2012.
3. A. S. Tanenbaum, *Modern Operating Systems*, 4/e, Pearson Education, 2017.
4. G. J. Nutt, *Operating Systems - A Modern Perspective,* 3/e, Pearson Education, 2009.

CS3004D SOFTWARE ENGINEERING

Prerequisites: CS2002D Program Design, CS2006D Discrete Structures

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+5P Hours)

Introduction to Software Engineering – Reasons for software project failure – Similarities and differences between software and other engineering products. Software Development Life Cycle (SDLC) – Overview of Phases. Detailed Study of Requirements Phase.

Module 2: (10T+14P Hours)

Principles of software Design - Problem partitioning (subdivision) - Power of Abstraction. Concept of functional decomposition – UML diagrams - emphasis on class, object, sequence, activity diagrams. ER diagrams. Introduction to architectural patterns including MVC.
Coding and Testing: Structured programming – Methods and tools for version control - Maintainability. Types of testing – Specification of test cases – Code review and inspection process.

Module 3: (10T+7P Hours)

Software Project Management: Introduction to metrics. Software Process Models. Costing, Scheduling and Tracking techniques.
Methods of software licensing including free and open source software licenses.

Module 4: (9T Hours)

Current trends in Software Engineering: Extreme Programming - Values, Principles, Practices. Agile approach and manifesto. Introduction to Service Oriented Architecture - Entities and Characteristics - Web Service as an example of SOA Implementation- Evolution of Web Services- Technologies behind Web Service - SOAP, WSDL,UDDI, BPEL -RESTful Web Service Architecture- Micro Services.

References:

1. R. S. Pressman, *Software Engineering: A Practitioner's Approach,* 6/e, McGraw Hill, 2008.
2. T. C. Lethbridge and R. Laganiere, *Object Oriented Software Engineering,* 1/e, Tata McGraw Hill,2004.
3. K. Beck, *Extreme Programming,* 2/e*,* Pearson Education, 2006.
4. C. Fowler, *The Passionate Programmer,* SPD Pvt. Ltd., 2009.

CS3005D COMPILER DESIGN

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (9T+10P Hours)

Introduction to Programming language translation. Lexical analysis: Specification and recognition of tokens.

Module 2: (10T+10P Hours)

Syntax analysis: Top-down parsing-Recursive descent and Predictive Parsers. Bottom-up Parsing- LR (0), SLR, and LR (1) Parsers.

Module 3: (10T+6P Hours)

Semantic analysis: Type expression, type systems, symbol tables and type checking.
Intermediate code generation: Intermediate languages. Intermediate representation - Three address code and quadruples. Syntax-directed translation of declarations, assignments statements, conditional constructs and looping constructs.

Module 4: (10 Hours)

Runtime Environments: Storage organization, activation records. Introduction to machine code generation and code optimizations.

References:

1. A. V. Aho, M. S. Lam, R. Sethi, and J. D. Ullman, *Compilers: Principles, Techniques and Tools*, Pearson Education, 2007.
2. A. W. Appel and J. Palsberg, *Modern Compiler Implementation in Java*, Cambridge University Press, 2002.
3. D. Grune, K. van Reeuwijk, H. E Bal, C. J. H. Jacobs, and K. Langendoen. *Modern Compiler Design*, 2/e, Springer 2012.

CS3006D COMPUTER NETWORKS

Prerequisites: CS2005D Data Structures and Algorithms

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Computer Networks and Internet, The network edge, The network core, Network access, Delay and loss, Protocol layers and services, Application layer protocols, Web 2.0, Socket Programming,

Module 2: (10T+7P Hours)

Transport layer services, UDP, TCP, New transport layer Protocols, Congestion control, New versions of TCP, Network layer services, Routing, IP, routing in Internet, Router, IPV6, Multicast routing.

Module 3: (10T+7P Hours)

Link layer services, Error detection and correction, Multiple access protocols, ARP, Ethernet, Hubs, Bridges, Switches, MPLS, VLAN.

Module 4: (09T+5P Hours)

wireless links, Mobility, Multimedia networking, Streaming stored audio and video, Real-time protocols, Network management.

References:

1. J. F. Kurose and K. W. Ross, *Computer Networking: A Top-Down Approach Featuring Internet*, 6/e, Pearson Education, 2012.
2. L. L. Peterson and B. S. Davie, *Computer Networks, A systems approach*, 5/e, Morgan Kaufmann, 2011.
3. A. S. Tanenbaum and D. J. Wetherall, *Computer Networks*, 5/e, Pearson, 2013.

CS4023D ARTIFICIAL INTELLIGENCE

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+4PHours)

Artificial Intelligence: Introduction,History and Applications; Intelligent Agents;Solving problems by Searching: Structures and Strategies for state space search- Data driven and goal driven search,Uninformed Search strategies, Informed(Heuristic) Search Strategies, Heuristic Functions, Local Search Algorithms and Optimization Problems, Searching with Nondeterministic actions, Constraint satisfaction, Using heuristics in games- Minimax Search, Alpha Beta Procedure,Stochastic Games.

Module 2: (10T+6PHours)

Knowledge representation: Knowledge based agents,Propositional calculus, First-Order Logic (Predicate Calculus),Inference in First-Order Logic, Forward and Backward chaining, Theorem proving by Resolution, Answer Extraction, AI Representational Schemes- Semantic Nets, Conceptual Dependency, Scripts, Frames, Planning,Planning and acting in the real world.

Module 3: (11T+8P Hours)

Learning: Learning From Examples, Knowledge in Learning, Learning probabilistic Models, Reinforcement Learning, The Genetic Algorithm- Genetic Programming, Overview of Expert System Technology, Introduction to Natural Language Processing.

Module 4: (8T+8PHours)

Languages and Programming Techniques for AI- Introduction to PROLOG and LISP, Search strategies and Logic Programming in LISP, Production System examples in PROLOG.

References:

1. S. Russell and P. Norvig, *Artificial Intelligence:A Modern Approach,* 2/e, Pearson Education, 2002.
2. G. F. Luger, *Artificial Intelligence- Structures and Strategies for Complex Problem Solving,* 4/e, 2002, Pearson Education.
3. E. Rich and K. Knight, *Artificial Intelligence,* 2/e, Tata McGraw Hill.
4. P. H. Winston, *LISP*, 3/e, Addison Wesley, 1989.
5. I. Bratko, *Prolog Programming for Artificial Intelligence,* 3/e, Addison Wesley, 2000.

CS4098D PROJECT: Part I

Prerequisites: NIL

L	T	P	C
-	-	6	3

Students shall form a team of at most four for the project and identify a faculty member as the project guide, with whom they associate for the project work for a period of two semesters.

In this part of the project, the team, in consultation with the guide shall identify an area of work and conduct a detailed literature survey of the relevant work in the area. The team shall then identify a problem and prepare a report of the problem they are going to work on for the second part of the project.

References:

1. G. J. Alred, C. T. Brusaw, and W. E. Oliu, *The Handbook of Technical Writing*, 11/e, Bedford/St. Martins, 2015.
2. G. R. Marczyk, D. DeMatteo, and D. Festinger, *Essentials of Research Design and Methodology,* John Wiley & Sons, Inc, 2005.

CS4099D PROJECT: Part II

Prerequisites: CS4098D Project: Part I

L	T	P	C
-	-	16	8

The team identified in Part I of the project will design a solution to the problem identified in the first semester. The solution shall be implemented and the results, observations and conclusions tabulated. The design, results and conclusions will be documented to form a project report which shall be presented.

References:

1. G. J. Alred, C. T. Brusaw, and W. E. Oliu, *The Handbook of Technical Writing*, 11/e, Bedford/St. Martins, 2015.
2. G. R. Marczyk, D. DeMatteo, and D. Festinger, *Essentials of Research Design and Methodology,* John Wiley & Sons, Inc, 2005.

CS2007D ENVIRONMENTAL STUDIES

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Definition, scope and importance - renewable and non-renewable resources - Natural resources - forest, water, mineral, food and energy and land resources - study of problems - Role of individual in conservation - equitable use of resources and sustainable lifestyles.

Module 2: (10 Hours)

Ecosystems - structure and function - producer, consumer and decomposer - energy flow - ecological succession- food chains- forest, grassland, desert and aquatic ecosystems - Biodiversity and conservation.

Module 3: (10 Hours)

Environmental pollution - air, water, soil, marine, thermal, nuclear and noise pollution- methods of prevention - waste management - disaster management - environmental ethics - sustainable development models - water conservation - climate change and global warming - ozone layer depletion - nuclear holocaust - case studies - consumerism and waste products.

Module 4: (9 Hours)

Human population and environment - family welfare - human health and environment - human rights.

References:

1. E. Bharucha, *Environmental Studies*, Universities Press, 2005.
2. UGC Syllabus on environmental studies available at http://www.ugc.ac.in/inside/syllabus.html accessed on 12-04-2018.

CS4021D NUMBER THEORY AND CRYPTOGRAPHY

Prerequisites : NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (12T+5P Hours)

Divisibility theory in integers: Extended Euclid's algorithm. Modular Arithmetic – exponentiation and inversion. Fermat's Little Theorem, Euler's Theorem. Solution to congruences, Chinese Remainder Theorem.

Module 2: (15T+15P Hours)

Review of abstract algebra: Study of Ring Zn, multiplicative group Zn* and finite field Zp – Gauss Theorem (cyclicity of Zp*) - Quadratic Reciprocity.
Primality Testing – Fermat test, Carmichael numbers, Solovay Strassen Test, Miller Rabin Test - detailed analysis.

Module 3: (12T+6P Hours)

Notions of security: Introduction to one secret key cryptosystem (DES) and one cryptographic hash scheme (SHA). Public Key Cryptosystems – Diffie Hellman Key Agreement Protocol, Knapsack crypto systems, RSA. Elgamal encryption and signature scheme. Key Management Protocols

References:

1. H. Delfs and H. Knebl, *Introduction to Cryptography: Principles and Applications*, Springer-Verlag, 2002.
2. S. Vaudenay, *A Classical Introduction to Cryptography: Applications for Communications Security*, Springer, 2009.
3. B. A. Forouzan and D. Mukhopadhyay, *Cryptography and Network Security,* 2/e*,* Tata McGraw Hill, 2010.

CS4022D PRINCIPLES OF PROGRAMMING LANGUAGES

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Programming Languages: Concepts and Constructs. Untyped Arithmetic Expressions – Introduction, Semantics, Evaluation.

Module 2: (10T+6P Hours)

Untyped Lambda Calculus – Basics, Semantics. Programming in Lambda Calculus.

Module 3: (10T+7P Hours)

Typed Arithmetic Expressions – Types and Typing relations, Type Safety.
Simply Typed Lambda Calculus – Function types, Typing relations, Properties of typing.

Module 4: (9T+6P Hours)

Extensions to Simply Typed Lambda Calculus – Unit type, Let bindings, Pairs, Records, Sums, Variants, References, Exceptions.

References:

1. B. C. Pierce, *Types and Programming Languages*, MIT Press, 2002.
2. D. A. Schmidt, *Programming Language Semantics. In Allen B. Tucker, Ed. Handbook of Computer Science and Engineering,* CRC Press, 1996.
3. L. Cardelli, *Type Systems. In Allen B. Tucker, Ed. Handbook of Computer Science and Engineering*, CRC Press, 1996.
4. M. L. Scott, *Programming Language Pragmatics*, 2/e, Elsevier, 2004.

CS4024D INFORMATION THEORY

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Foundations: Review of probability theory, entropy and information, random sources, i.i.d and Markov sources, discrete finite state stationary Markov sources, Entropy rate of stationary sources, Computation of stationary distributions.

Module 2: (10 Hours)

Source Coding: Prefix and uniquely decodable codes - Kraft's and Macmillan's inequalities - Shannon's source coding theorem - Shannon Fano code, Huffman code - optimality.

Module 3: (10 Hours)

Channel Coding: BSC and BEC channel models - Channel capacity - Shannon's channel coding theorem - existence of capacity achieving codes for BEC, Fano-Elias Inequality.

Module 4: (9 Hours)

Cryptography: Information theoretic security - Perfect secrecy - Shannon's theorem - perfectly secret codes - Introduction to computational security and pseudo random sources.

References:

1. T. M. Cover and J. A. Thomas, *Elements of Information Theory*, Addison Wesley, 1999.
2. D. J. Mackay, *Information Theory, Inference and Learning Algorithms*, Cambridge University Press, 2002.
3. H. Delfs and H. Knebl, *Introduction to Cryptography,* 2/e, Springer, 2010.

CS4025D RANDOMIZED ALGORITHMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: Basics (10T Hours)

Sample Space, Events, Conditional probability, Independent events, Random Variables, Linearity of Expectation, Probabilistic method, Markov and Chebyshev inequalities, Moments of a Random variable, Chernoff bounds, Martingales and Azuma's inequality.

Module 2: (10T+10P Hours)

Randomized data structures and algorithms : Skip lists, Hashing, Randomized min-cut, Verifying matrix multiplication, Randomized quicksort, Randomized selection, Coupon Collector's algorithm, Randomized pattern matching. Number theoretic algorithms: Primality testing -- Miller Rabin test.

Module 3: (9T+7P Hours)

Markov chains and random walks, stationarity, Markov chain Monte Carlo (MCMC) methods volume estimation. Randomized Complexity Classes.

Module 4: (10T+9P Hours)

Probabilistic Method and Derandomization, The basic counting argument, The Expectation argument, Derandomization using conditional expectation, Sample and Modify, The Second Moment method, Lovasz Local Lemma, Explicit Constructions using the Local Lemma, Schwartz–Zippel lemma.

References:

1. R. Motwani and P. Raghavan, *Randomized Algorithms*, Cambridge University Press, 1995.
2. M. Mitzenmacher and E. Upfal, *Probability and Computing: Randomization and probabilistic techniques in algorithms and data analysis,* 2/e, Cambridge University Press, 2017.
3. C. H. Papadimitriou, *Computational Complexity*, Addison Wesley, 1994.

CS4026D COMBINATORIAL ALGORITHMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Network Flows: Review of graph theory – spanning trees, shortest paths. Connectivity, Network Flows - Max flow min cut theorem, algorithms of Ford-Fulkerson, Edmond Karp, preflow-push algorithms.

Module 2: (10T+5P Hours)

Primal Dual Theory: Linear programming, Primal dual theory, LP-duality based algorithm design. Applications to Network flow and other combinatorial problems, Applications to graph theory - Konig's theorem, Hall's theorem, Menger's theorem.

Module 3: (9T+7P Hours)

Matching Theory: Tutte's theorem, Primal dual algorithms – Hungarian algorithm, Hopcroft Karp algorithm, Edmonds' 'Blossom' maximum matching algorithm for general graphs. Application to marriage problems.

Module 4: (10T+7P Hours)

Approximation: Primal Dual approximation algorithms for set cover, Maximum satisfiability, Steiner tree, multicut, Steiner forest, sparsest cut and k-medians.

References:

1. D. West, *Graph Theory*, Prentice Hall, 2002.
2. D. Jungnickel, *Graphs Networks and Algorithms*, Springer 2005.
3. U. Vazirani, *Approximation Algorithms*, Springer 2003.
4. D. P. Williamson and D. B. Shmoys, *The Design of Approximation Algorithms*, Cambridge University Press, 2011.

CS4027D TOPICS IN ALGORITHMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Computational Linear Algebra: LUP decomposition, matrix inversion, Strassen's algorithm, least squares approximation. Fourier transform: Discrete Fourier transform and the fast fourier transform algorithm.

Module 2: (10T+6P Hours)

Advanced data structures: Balanced binary search trees, B tree, Splay trees, Skip lists, Red black tree. Fibonacci heaps and self-adjusting search trees, Splay trees, linking and cutting trees. Universal hashing.

Module 3: (10T+6P Hours)

Geometric algorithms: Selection algorithms and application to convex hull, Ultimate convex hull algorithm, linear programming in two and three dimensions.

Module 4: (9T+7P Hours)

Integer sorting and improved algorithms for shortest paths and minimum spanning tree. Preflow-push algorithms and Scaling algorithms for network flow problems.

References:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms*, 3/e, Prentice Hall India, 2010.
2. C. H. Papadimitriou, *Computational Complexity*, Addison Wesley, 1994.
3. D. C. Kozen, *The Design and Analysis of Algorithms*, Springer Verlag N.Y, 1992.

CS4028D QUANTUM COMPUTATION

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Review of Linear Algebra. The postulates of quantum mechanics. Review of Theory of Finite Dimensional Hilbert Spaces and Tensor Products, spectral theorem for Hermitian and Normal operators.

Module 2: (10 Hours)

Complexity classes. Models for Quantum Computation. Qubits. Single and multiple qubit gates. Quantum circuits. Bell states. Single qubit operations. Controlled operations and measurement. Universal quantum gates. Quantum Complexity classes and relationship with classical complexity classes

Module 3: (10 Hours)

Quantum Algorithms – Quantum search algorithm - geometric visualization and performance.
Quantum search as a quantum simulation. Speeding up the solution of NP Complete problems.
Quantum search as an unstructured database. Grover's and Shor's Algorithms.

Module 4: (09 Hours)

Introduction to Quantum Coding Theory. Quantum error correction. The Shor code. Discretization of errors, Independent error models, Degenerate Codes. The quantum Hamming bound. Constructing quantum codes – Classical linear codes, Shannon entropy and Von Neumann Entropy.

References:

1. M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information,* Cambridge, UK, Cambridge University Press, 2002.
2. J. Gruska, *Quantum Computing*, McGraw Hill, 1999.
3. A. Peres, *Quantum Theory: Concepts and Methods,* Springer, 1993.

CS4029D TOPICS IN COMPLEXITY

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Hours)

Hardness of approximation: Probabilistically checkable proofs, PCP theorem (no proof), Proofs for weaker versions of PCP theorem, Hardness of approximation, gap reductions, hardness results for 3SAT, Clique, vertex cover etc. reductions using expander graphs,

Module 2: (13 Hours)

Circuit lower bounds - Switching lemma, classes ACC0 and TC0. Circuit lower bound for PARITY and MAJORITY. Inequivalence of ACC0 and NEXP (no proof).

Module 3: (13 Hours)

Cryptography - one-way functions and pseudo random generators, Yao's theorem, Goldreich-Levin theorem, zero knowledge proofs.

References:

1. S. Arora and B. Barak, *Computational Complexity: A Modern Approach*, Cambridge University Press, 2009.
2. D. C. Kozen, *Theory of Computation,* Springer, 2007.
3. C. H. Papadimitriou, *Computational Complexity*, 1/e, Addison Wesley, 1993.

CS4030D COMPUTATIONAL COMPLEXITY

Prerequisites: NIL

L	T	P	C
4	0	0	4

Total hours: 52

Module 1: (14 Hours)

Review of Complexity Classes: L, NL, P, NP, PSPACE and EXP, log-space and polynomial-time reductions, completeness, Hierarchy theorems, Savitch, and Immerman theorems.

Module 2: (14 Hours)

Circuit complexity, P/Poly, NC and AC, P-completeness, polynomial hierarchy, Karp Lipton theorem, alternation, relationship between circuit depth and space complexity.

Module 3: (12 Hours)

Randomized Complexity classes: Adleman's theorem, Sipser Gacs theorem, counting class, #P, Valiant's Theorem, Toda's theorem (no proof).

Module 4: (12 Hours)

Arthur Merlin games, Graph Isomorphism problem, Goldwasser-Sipser theorem, Interactive Proofs, Shamir's theorem.

References:

1. S. Arora and B. Barak, *Computational Complexity: A Modern Approach*, Cambridge University Press, 2009.
2. C. H. Papadimitriou, *Computational Complexity*, 1/e, Addison Wesley, 1993.
3. R. Motwani and P. Raghavan, *Randomized Algorithms*, Cambridge University Press, 1995.
4. V. Vazirani, *Approximation Algorithms*, 1/e, Springer, 2004.

CS4031D COMPUTATIONAL ALGEBRA

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+6P Hours)

Number Theory: Review of groups and rings and vector spaces, Euclid's algorithm, Structure of the ring Zn Algorithms for computation in the ring Zn - modular inversion, exponentiation, Chinese remaindering.

Module 2: (10T+6P Hours)

Finite fields: Structure theory of finite fields - Factorization of polynomials over finite fields - Berlekamp's algorithm, Cantor Zassenhaus algorithm, Fourier Transform algorithm for finite fields.

Module 3: (9T+7P Hours)

Primality Testing: Solovay Strassen test, Miller Rabin test, Agrawal, Kayal Saxena algorithm.

Module 4: (10T+7P Hours)

Applications: Euclid's algorithm for rational polynomial approximation and decoding BCH and RS codes. Applications to public key cryptography.

References:

1. V. Shoup, *A computational Introduction to Number Theory and Algebra*, Cambridge University Press, 2005.
2. H. Delfs and H. Knebl, *Introduction to Cryptography,* Springer, 1998.
3. J. von zur Gathen, *Modern Computer Algebra*, Cambridge University Press, 2003.
4. W. C. Huffman and V. Pless, *Fundamentals of Error Correcting Codes*, Cambridge University press, 2003.

CS4032D COMPUTER ARCHITECTURE

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Fundamentals - Technology trend -performance measurement - Comparing and summarizing performance-quantitative principles of computer design - Amdahl's law - instruction set architectures - memory addressing - type and size of operands - encoding an instruction set - role of compilers - Review of pipelining - MIPS architecture Memory hierarchy design - reducing cache misses and miss penalty, reducing hit time Main memory organization - virtual memory and its protection.

Module 2: (10T+7P Hours)

Instruction level parallelism and its limits - static and dynamic scheduling - static and dynamic branch prediction - multiple issue processor - multiple issue with dynamic scheduling-hardware based speculation - limitation of ILP-Multithreading,

Module 3: (10T+7P Hours)

Multiprocessor and thread level parallelism- classification of parallel architecture-models of communication and memory architecture-Symmetric shared memory architecture-cache coherence protocols-distributed shared memory architecture-directory based cache coherence protocol - Memory consistency-relaxed consistency models.

Module 4: (9T +5P Hours)

Data Level Parallelism-Vector processors-SIMD extensions, GPU, GPU and CUDA, Overview of CUDA C; threads, blocks and grids, warps, different GPU memories, Kernel-Based Parallel Programming, Request level parallelism, Domain specific Architecture

References

1. J. L Hennessy and D. A. Patterson, A.*Computer Architecture: A Quantitative approach*, 6/e, Morgan Kaufmann, 2017.
2. D. A. Patterson and J. L. Hennessy, *Computer Organisation and Design: The Hardware/ Software Interface*, 5/e, Harcourt Asia Pte Ltd (Morgan Kaufman), 2014.

CS4033D DISTRIBUTED COMPUTING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Characteristics of Distributed Systems, Distributed systems Versus Parallel systems, Models of distributed systems**,** Happened Before and Potential Causality Model, Models based on States, Logical clocks, Vector clocks, Verifying clock algorithms, Direct dependency clocks.

Module 2: (10T+7P Hours)

Mutual exclusion using Timestamps, Distributed Mutual Exclusion (DME) using timestamps, token and Quorums, Centralized and distributed algorithms, proofs of correctness and complexity analysis. Drinking philosophers problem, Dining philosophers problem under heavy and light load conditions. Implementation and performance evaluation of DME algorithms.

Module 3: (10T+7P Hours)

Leader election algorithms, Global state detection, Global predicates, Termination Detection, Control of distributed computation, disjunctive predicates. Performance evaluation of leader election algorithms on simulated environments.

Module 4: (9T+5P Hours)

Self stabilization, knowledge and common knowledge, Distributed consensus, Consensus under Asynchrony and Synchrony, Checkpointing for Recovery, R- Graphs

References:

1. V. K. Garg, *Elements of Distributed Computing*, Wiley & Sons, 2002.
2. S. Ghosh, *Distributed Systems An Algorithmic Approach*, Chapman & Hall, CRC Computer and Information Science Series, 2006.
3. A. S. Tanenbaum and M. V. Steen, *Distributed Systems: Principles and Paradigms*, 2/e, Pearson, 2007.
4. G. Coulouris, J. Dollimore, T. Kindberg, and G. Blair, *Distributed Systems: Concepts and Design*, 5/e, Addison Wesley, 2011.
5. R. Chow and T. Johnson, *Distributed Operating Systems and Algorithms*, Addison Wesley, 2002.

CS4034D MIDDLEWARE TECHNOLOGIES

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P
Module 1: (10T+7P Hours)

Publish/Subscribe matching algorithm, event based systems, notification filtering mechanisms, Composite event processing, content based routing, content based models and matching, matching algorithms, distributed hash tables (DHT)

Module 2: (10T+7P Hours)

Distributed notification routing, content based routing algorithms, engineering event based systems, Accessing publish/subscribe functionality using APIs. Scoping, event based systems with scopes, notification mappings, transmission policies, implementation strategies for scoping.

Module 3: (9T+5P Hours)

Composite event detection, detection architectures, security, fault tolerance, congestion control, mobility, existing notification standards- JMS, DDS, HLA.

Module 4: (10T+7P Hours)

Topic based systems, Overlays, P2P systems, overlay routing, Case studies- REBECA, HERMES, Gryphon. Commercial systems- IBM Websphere MQ, TIBCO Rendezvous.

References:

1. G. Muhl, L. Fiege, and P. R. Pietzuch, *Distributed Event Based Systems,* Springer, 2006.
2. C. Britton and P. Bye, *IT Architectures and Middleware*, 2/e, Pearson Education, 2005.
3. Y. Diao and M. J. Franklin, *Query Processing for High-Volume XML Message Brokering*, VLDB, 2003.
4. C. Chan, M. Garofalakis, and R. Rastogi, *RE-Tree: An Efficient Index Structure for Regular Expressions*, VLDB, 2002.

CS4035D COMPUTER SECURITY

Prerequisites: CS4021D Number Theory and Cryptography

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (15T+0P Hours)

Review of Cryptography Fundamentals - Cryptographic Protocols for Authentication - Authentication Protocols: One way and Mutual Authentication, Challenge Response protocols, Lamport's scheme, Needham Schroeder protocol. Interactive proof systems, Zero Knowledge Proof systems – soundness and completeness – Fiat-Shamir identification scheme.
Access Control – MAC, DAC, RBAC. Formal models of security - BLP, Biba, Chinese Wall and Clark Wilson. Overview of SELinux.

Module 2: (15T+18P Hours)

Network Security - Security at different layers – IPSec / SSL-TLS / PGP.
Principles of Secure Design - Software vulnerabilities - Buffer and stack overflow, Phishing. Malware - Viruses, Worms and Trojans.
Security problems in network domain - DoS, DDoS, ARP spoofing and session hijacking. DNS attacks and DNSSEC. Cross-site scripting XSS, SQL injection attacks.
Defense Mechanisms - Intrusion Detection Systems (IDS) and Firewalls.

Module 3: (9T+8P Hours)

Cloud computing architecture - Introduction from a security perspective - guiding principles for designing and implementing appropriate safeguards in the cloud domain.
Security in current applications – Two out of the following four areas may be subjected to a detailed study from the security perspective. Online Banking, Digital Currency, E-Voting, Internet of Things.

References:

1. B. Menezes, *Network security and Cryptography*, Cengage Learning India, 2010.
2. B. A. Forouzan and D. Mukhopadhyay, *Cryptography and Network Security,* 2/e*,* Tata McGraw Hill, 2010.
3. D. Gollmann, *Computer Security*, John Wiley and Sons Ltd., 2006.
4. C. Kaufman, R. Perlman, and M. Speciner, *Network Security,* Pearson India, 2017.

CS4036D ADVANCED DATABASE MANAGEMENT SYSTEMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Distributed database concepts - overview of client - server architecture and its relationship to distributed databases, Concurrency control Heterogeneity issues, Persistent Programming Languages, Object Identity and its implementation, Clustering, Indexing, Client Server Object Bases, Cache Coherence.

Module 2: (10T+7P Hours)

Parallel Databases: Parallel Architectures, performance measures, shared nothing/shared disk/shared memory based architectures, Data partitioning, Intra-operator parallelism, Pipelining, Scheduling, Load balancing, Query processing- Index based, Query optimization: cost estimation, Query optimization: algorithms, Online query processing and optimization, XML, DTD, XPath, XML
indexing, Adaptive query processing

Module 3: (10T+7P Hours)

Advanced Transaction Models: Savepoints, Sagas, Nested Transactions, Multi Level Transactions. Recovery: Multi-level recovery, Shared disk systems, Distributed systems 2PC, 3PC, replication and hot spares, Data storage, security and privacy- Multidimensional K- Anonymity, Data stream management.

Module 4: (9T+5P Hours)

Models of Spatial Data: Conceptual Data Models for spatial databases (e.g. pictogram enhanced ERDs), Logical data models for spatial databases: raster model (map algebra), vector model, Spatial query languages, Need for spatial operators and relations, SQL3 and ADT. Spatial operators, OGIS queries

References:

1. A. Silberschatz, H. Korth, and S. Sudarshan. *Database System Concepts*, 5/e, McGraw Hill, 2005.
2. S. Shekhar and S. Chawla. *Spatial Databases: A Tour*, Prentice Hall, 2003.
3. R. H. Guting and M. Schneider, *Moving Objects Databases,* Morgan Kaufman, 2005.
4. R. Elmasri and S. Navathe, *Fundamentals of Database Systems,* 5/e, Benjamin- Cummings, 2007.

CS4037D CLOUD COMPUTING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

New Computing Paradigms & Services: Cloud computing , Edge computing , Grid computing , Utility computing , Cloud Computing Architectural Framework, Cloud Deployment Models, Virtualization in Cloud Computing, Parallelization in Cloud Computing, Security for Cloud Computing, Cloud Economics , Metering of services.

Module 2: (10T+7P Hours)

Cloud Service Models: Software as a Service (SaaS), Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Service Oriented Architecture (SoA), Elastic Computing, On Demand Computing, Cloud Architecture, Introduction to virtualization.

Module 3: (10T+6P Hours)

Types of Virtualization, Grid technology , Browser as a platform, Web 2.0, Autonomic Systems, Cloud Computing Operating System, Deployment of applications on the cloud, Case studies- Xen, VMware, Eucalyptus, Amazon EC2.

Module 4: (9T+6P Hours)

Introduction to Mapreduce, Information retrieval through Mapreduce, Hadoop File System, GFS, Page Ranking using Map Reduce, Security threats and solutions in clouds, mobile cloud computing, Case studies- Ajax, Hadoop.

References:

1. T. White, *Hadoop: The Definitive Guide*, O'Reilly Media, 2009
2. J. Venner, *Pro Hadoop*, Apress, 2009
3. T. Chou*, Introduction to cloud computing & Business*, Active Book Press, 2010

CS4038D DATA MINING

Prerequisites: CS3002D Database Management Systems

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Introduction to data mining-challenges and tasks Data preprocessing data analysis, measures of similarity and dissimilarity, Data visualization –concepts and techniques

Module 2: (10T+7P Hours)

Classification- decision tree-performance evaluation of the classifier, comparison of different classifiers, Rule based classifier, Nearest-neighbor classifiers-Bayesian classifiers-support vector machines, Class imbalance problem

Module 3: (10T+6P Hours)

Association analysis –frequent item generation rule generation, evaluation of association patterns

Module 4: (9T+6P Hours)

Cluster analysis,-types of clusters, K means algorithm, cluster evaluation, application of data mining to web mining and Bioinformatics

References:

1. P. Tan, M. Steinbach, and V. Kumar, *Introduction to Data Mining*, Pearson Education 2006.
2. J. Han and M. Kamber, *Data Mining: Concepts and Techniques,* 2/e, Morgan Kaufmann, 2005.
3. T. Hastie, R. Tibshirani, and J. Friedman, *The Elements of Statistical Learning - Data Mining, Inference, and Prediction,* 2/e, Springer, California, 2008.

CS4039D MULTI AGENT SYSTEMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Introduction to agent and multi-agent systems, different types of agents, abstract architecture, distributed problem solving, application areas, Software tools for modeling Multi-Agent Systems

Module 2: (10T+7P Hours)

Agent communication, communication languages KQML and FIPA ACL Communication policies and protocols, Protocol Modeling

Module 3: (10T+6P Hours)

Negotiation in multi-agent- agent environment, game theoretical model , heuristic approach, argumentation based approach

Module 4: (9T+6P Hours)

Distributed decision making – Evaluation criteria - Social welfare, Pareto Efficiency, Individual Rationality, Stability, Application of multiagent systems in complex distributed problem solving, Modeling distributed multi-agent systems.

References:

1. M. Wooldridge, *An Introduction to multiagent systems*, Wiley, 2009.
2. R. Norvig, *Artificial Intelligence: A modern approach*, Prentice Hall, 2010.

CS4040D BIOINFORMATICS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Molecular Biology primer, gene structure and information content, Bioinformatics tools and databases, genomic information content, Sequence Alignment, Algorithms for global and local alignments, Scoring matrices, Dynamic Programming algorithms.

Module 2: (10T+7P Hours)

Introduction to Bio-programming Languages, Motif finding, Gene Prediction, Molecular Phylogenetics, Phylogenetic trees, Algorithms for Phylogenetic Tree construction.

Module 3: (9T+6P Hours)

Combinatorial Pattern Matching, Repeat finding, Keyword Trees, Suffix Trees, Heuristic similarity search algorithms, Approximate Pattern Matching.

Module 4: (10T+6P Hours)

Microarrays, Gene expression, Algorithms for Analyzing Gene Expression Data, Protein and RNA structure prediction, Algorithms for Structure Prediction, Emerging Trends in Bioinformatics Algorithms and Databases.

References:

1. N. C. Jones and P. A. Pevzner, *An Introduction to Bioinformatics Algorithms*, MIT Press, 2004.
2. D. E. Krane and M. L. Raymer, *Fundamental Concepts of Bioinformatics*, Pearson Education, 2003.
3. T. K. Attwood and D. J. Parry-Smith, *Introduction to Bioinformatics,* Pearson Education, 2003.
4. Current Literature.

CS4041D NATURAL LANGUAGE PROCESSING

Prerequisites: CS2005D Data Structures and Algorithms

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Introduction to Natural Language Processing, Different Levels of language analysis, Representation and understanding, Linguistic background. Grammars and parsing, Top down and Bottom up parsers.

Module 2: (9T+6P Hours)

Transition Network Grammars, Feature systems and augmented grammars, Morphological analysis and the lexicon, Parsing with features, Augmented Transition Networks.

Module 3: (10T+7P Hours)

Grammars for natural language, Movement phenomenon in language, Handling questions in context free grammars, Hold mechanisms in ATNs, Gap threading, Human preferences in parsing, Shift reduce parsers, Deterministic parsers, Statistical methods for Ambiguity resolution

Module 4: (10T+6P Hours)

Semantic Interpretation, word senses and ambiguity, Basic logical form language, Encoding ambiguity in logical from, Thematic roles, Linking syntax and semantics, Information Retrieval, Recent trends in NLP.

References:

1. J. Allen, *Natural Language Understanding,* 2/e, Pearson Education, 2003.
2. T. Siddiqui and U. S. Tiwary, *Natural Language Processing and Information Retrieval*, Oxford University Press, 2008.
3. D. Jurafsky and J. H. Martin, *Speech and Language Processing,* Pearson Education, 2000.

CS4042D WEB PROGRAMMING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Internet and its architecture, Client Server Architecture- Creating an Internet Client, Application Protocols and http, Presentation aspects html, CSS and Javascript, Creating a web server, Serving Dynamic Content- CGI – overview of technologies like PHP, AJAX.

Module 2: (10T+7P Hours)

Web development frameworks – Detailed study of one open source web framework - Ruby Scripting, Ruby on rails – Design, Implementation and Maintenance aspects.

Module 3: (10T+6P Hours)

Designing Web Services- Web Technologies- SOAP, WSDL, UDDI, BPEL- Implementing a simple webservice, RESTful web service.

Module 4: (9T+6P Hours)

Shared memory synchronization, Performance measurement and workload models. Comparison using existing benchmarks. Designing web solutions defensively - evaluation of threats and mitigation strategy

References:

1. D. Thomas, C. Fowler, and A. Hunt, *Programming Ruby: The Pragmatic Programmer's Guide,* 3/e, Pragmatic Programmers, May 2008.
2. L. Richardson and S. Ruby, *Restful Web Services*, 1/e, O Reilly, 2007.

CS4043D IMAGE PROCESSING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+8P Hours)

Fundamentals of Image processing: Digital image representation, Elements of Digital image processing systems, Image model, Sampling and Quantization, Basic relations between pixels.
Image transforms: One dimensional Fourier transform, Two dimensional Fourier transform, Properties of two dimensional Fourier transform. Walsh transform, Hadamard transform, Discrete cosine transform, Haar transform, Slant transform.

Module 2: (10T+6P Hours)

Image enhancement techniques: Spatial domain methods, Frequency domain methods, Intensity transform, Histogram processing, Image subtraction, Image averaging, Smoothing filters, Sharpening filters, Spatial masks from frequency domain.

Module 3: (10T+6P Hours)

Image Segmentation: Thresholding: Different types of thresholding methods, Point detection, Edge detection: Different types of edge operators, Line detection, Edge linking and boundary detection, Region growing, Region splitting, Region Merging.

Module 4: (9T+6P Hours)

Image Data Compression: Fundamentals, Compression models, Error free compression, Lossy Compression, Image compression standards.
Applications of Image Processing: Medical imaging, Robot vision, Character recognition, Remote Sensing.

References:

1. R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, Addison-Wesley Publishing Company, 2007.
2. A. K. Jain, *Fundamentals of Digital Images Processing*, Pearson Education India, 2015

CS4044D MACHINE LEARNING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Introduction: Machine Perception , Pattern Recognition Systems, The Design Cycle, Learning and Adaptation.
Bayes Decision Theory: Bayes Decision Theory, Minimum Error rate Classification, Classifiers, Discriminant functions and Decision Surfaces, Normal Density, Discriminant functions for the Normal Density, Bayes Decision Theory for Discrete features

Module 2: (10T+7P Hours)

Parameter Estimation :Maximum Likelihood Estimation,Maximum A Posteriori Estimation and Bayesian Parameter Estimation. Gaussian Case and General Theory.Non Parametric Techniques: Density Estimation, Parzen Windows , K- Nearest Neighbor Estimation,NN rule, Metrics and NN Classification, Unsupervised Methods - Clustering Algorithms- K Means, Gaussian Mixture Models, Fuzzy Classification.

Module 3: (10T+7P Hours)

Linear Discriminant Functions : Linear Discriminant Functions and Decision Surfaces, Generalized Discriminant Functions, The two-category linearly separable case , Minimizing the perceptron criterion function, relaxation procedures, non- separable behavior, Minimum Squared- Error procedures.
Linear Methods : Linear regression, logistic regression, Principal Component Analysis,Fisher's Linear Discriminant Analysis.
Non-linear methods - Kernel Methods - Kernel version of PCA, LDA,SVMs

Module 4: (9T+5P Hours)

Multi Layer Neural Networks : Feedforward Operation, Classification, Back – propagation Algorithm, Error Surfaces, Back-propagation as Feature mapping, COnvolutional Neural Networks and Deep Learning.

References:

1. R. O. Duda, P. E. Hart, and D. G. Stork, *Pattern Classification* , John-Wiley, 2004.
2. J. T. Tou and R. C. Gonzalez, *Pattern Recognition Principles*, Wiley, 1974.
3. C. M. Bishop, *Pattern Recognition and Machine Learning,* Springer, 2006.

CS4045D MEDICAL IMAGE PROCESSING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Introduction to digital image processing: images, image quality, basic operations.
Radiography: Introduction, X-rays, interaction with matter, detectors, dual energy imaging, quality clinical use, biologic effect and safety, Fourier Slice Theorem Basics.

Module 2: (10T+7P Hours)

X-ray Computed tomography: Introduction, X-ray detectors in CT, imaging, cardiac CT, image quality, clinical use, biologic effects and safety.
Magnetic resonance imaging: Introduction, physics of transmitted signal, interaction with tissue, signal detection and detector, imaging. Biologic effects and safety

Module 3: (10T+7P Hours)

Nuclear imaging, Introduction, radionuclides, interaction of Gamma-photons and particles with matter, data acquisition, imaging, image quality, equipment, clinical use, biologic effects and safety
Ultrasound imaging: Physics of acoustic waves, generation and detection of ultrasound, grayscale imaging, Doppler imaging, image quality, equipment, clinical use, biologic effects and safety.

Module 4: (9T+5P Hours)

Medical image analysis: Manual and automated analysis, computation strategies for automated medical image analysis, pixel classification.

References:

1. P. Suetens, *Fundamentals of medical imaging*, Cambridge University Press, 2009.
2. J. A. Bushberg et. al., *The Essential Physics of Medical Imaging,* 2/e, L. Williams and Wilkins, 2002.

CS4046D COMPUTER VISION

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (9T+ 6P Hours)

Introduction and overview, pinhole cameras, radiometry terminology. Sources, shadows and shading: Local shading models- point, line and area sources; photometric stereo. Color: Physics of color; human color perception, Representing color; A model for image color; surface color from image color.

Module 2: (10T+ 8P Hours)

Linear filters: Linear filters and convolution; shift invariant linear systems- discrete convolution, continuous convolution, edge effects in discrete convolution; Spatial frequency and fourier transforms; Sampling and aliasing; filters as templates; Normalized correlations and finding patterns. Edge detection: Noise; estimating derivatives; detecting edges. Texture: Representing texture; Analysis using oriented pyramid; Applications; Shape from texture. The geometry and views: Two views.

Module 3: (10T+ 6P Hours)

Stereopsis: Reconstruction; human stereo; Binocular fusion; using color camera.Structure from Motion;Motion Segmentation by Parameter Estimation

Module 4: (10T+ 6P Hours)

Segmentation by clustering: Human vision, applications, segmentation by graph theoretic clustering. Segmentation by fitting a model, Hough transform; fitting lines, fitting curves;Object Detection and Classification.

References:

1. D. A. Forsyth and J. Ponce, *Computer Vision- A modern approach*, Pearson education series, 2015.
2. R. J. Schalkoff, *Digital Image Processing and Computer Vision*, John Wiley, 2004.
3. R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer-Verlag London Limited 2011.
4. E. R. Davies, *Machine Vision:Theory Algorithms and Practices,* Elsevier, 2004.

CS4047D COMPUTER GRAPHICS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (9T+5P Hours)

Graphics Pipeline - overview of vertex processing, primitive generation, transformations and projections, clipping, rasterization, fragment processing - Graphics Hardware - overview of GPU architecture, how GPUs SIMD architecture suits computer graphics.

Module 2: (10T+7P Hours)

Coordinate Systems - representations, homogeneous coordinates, object, camera, world, and screen coordinate system, changing coordinate systems. Transformations - affine transformations, translation, rotation, scaling in homogeneous coordinates, matrix representations, cumulation of transformations. Viewing and Projections - orthographic and perspective projection, camera positioning, Hidden Surface Removal - its importance in rendering, z buffer algorithm, clipping, culling, Data Structures for efficient implementation of the transformations and projections.

Module 3: (10T+7P Hours)

Lighting and Shading - light sources, normal computation, reflection models, flat and smooth shading , Introduction to Textures and Mapping - Rendering Techniques - slicing, volume rendering, iso-surface extraction, ray casting, multiresolution representations for large data rendering. Data Structures for efficient implementation.

Module 4: (10T+7P Hours)

Geometric Modelling - Data structures - tree representations, hierarchical models, scene graphs - particle systems and representations - introduction to modeling and solving dynamics based on physics, Introduction to Curves Surfaces (Bezier, splines) and Meshes - structured and unstructured.

References:

1. E. S. Angel, *Interactive Computer Graphics, A top-down approach with OpenGL*, 5/e, Pearson Education, 2009.
2. D. Hearn and M. P. Baker, *Computer Graphics with OpenGL*, 3/e, Prentice Hall, 2003.
3. S. Marschner and P. Shirley, *Fundamentals of Computer Graphics*, 4/e, CRC Press, 2015.

CS4048D MATHEMATICAL FOUNDATIONS OF MACHINE LEARNING

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1: (09 hours)

Review of Probability Theory: Discrete and Continuous Random Variables, Joint and Marginal Distributions, Markov, Chebyshev, Jensen and Hausdorff Inequalities, Law of Large Numbers, Central Limit Theorem (No proof).
Classification and Estimation: Bayes classifier, maximum likelihood and Bayesian estimation techniques.

Module 2: (10 hours)

Review of Linear Algebra: Vector spaces, Rank Nullity Theorem, Metric and Normed Linear Spaces, Inner product spaces, Gram Schmidt Orthogonalization, Projections and Orthogonal Projections, Introduction to Hilbert spaces.
Orthogonal Decomposition algorithms: Eigen Decomposition, Singular Value Decomposition, Principal component analysis, LU, QR, Cholesky Decompositions, Least Squares Approximation

Module 3: (10 hours)

Review of Multivariate Analysis: Sequences and Limits, Differentiability, Level Sets and Gradients, multivariate Taylor Series.
Unconstrained Optimization: Conditions for Local Minimizers of Continuously Differentiable Functions, Gradient Search, Analysis of Newton's method, Levenberg-Marquardt Modification, Quasi-Newton Methods, Rank One Correction Formula, DFP and BFGS Algorithms.

Module 4: (10 hours)

Constrained Optimization: Tangent and Normal Spaces, Lagrange Condition, Second-Order-Conditions, Karush-Kuhn-Tucker Condition. Convex Optimization: Lagrange and Fenchel Duality, Proximal Algorithms, ADMM Algorithm.

References:

1. R. S. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, Academic Press, 2014.
2. K. Hoffman and R. Kunze. *Linear Algebra*, 2/e, Prentice Hall of India, 1990.
3. E. K. P. Chong and S. H. Zak, *An Introduction to Optimization*, 2/e, John Wiley & Sons, 2004.
4. B. Stephen and L. Vandenberghe, *Convex Optimization*, Cambridge University Press, 2004.
5. J. Eckstein and W. Yao, *Augmented Lagrangian and Alternating Direction Methods for Convex Optimization: A Tutorial and some Illustrative Computational Results*, *RUTCOR Research Reports* 32, 2012.

CS4049D ADVANCED COMPUTER NETWORKS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Introduction- Internet design philosophy, Layering and end to end design principle. MAC protocols for high-speed LANS, MANs, Wireless LANs and mobile networks, VLAN. Fast access technologies.

Module 2: (10T+7P Hours)

IPv6: Why IPv6, Basic protocol, extensions and options, Support for QoS, Security, Neighbour discovery, Auto-configuration, Routing. Changes to other protocols. Application Programming Interface for IPv6, 6bone. IP Multicasting, Wide area multicasting, Reliable multicast. Routing layer issues, ISPs and peering, BGP, IGP, Traffic Engineering, Routing mechanisms: Queue management, Packet scheduling. MPLS, VPNs

Module 3: (10T+7P Hours)

TCP extensions for high-speed networks, Transaction-oriented applications. New options in TCP, TCP performance issues over wireless networks, SCTP, DCCP.

Module 4: (9T+5P Hours)

DNS issues, other naming mechanisms, Overlay networks, P2P networks, Web server systems, Web 2.0, Internet traffic modelling, Internet measurements. Security – Firewalls, Unified threat Management System, Network Access Control.

References:

1. A. Farrel, *The Internet and its protocols a comparative approach*, Elsevier, 2005
2. M. Gonsalves and K. Niles, *IPv6 Networks,* McGraw Hill, 1998.
3. W. R. Stevens, *TCP/IP Illustrated*, Volume 1: The protocols, Addison Wesley, 1994.
4. G. R. Wright, *TCP/IP Illustrated,* Volume 2: The Implementation, Addison Wesley, 1995.

CS4050D DESIGN AND ANALYSIS OF ALGORITHMS

Prerequisites: CS2005D Data Structures and Algorithms

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Analysis: RAM model, Asymptotic Analysis, Recurrence relations, Probabilistic analysis, Worst and Average Case Analysis of Sorting Algorithms, Binary search and Hashing algorithms, Lower bound proofs for the above problems, Amortized analysis - Analysis of Knuth-Morris-Pratt algorithm, Amortized weight balanced trees

Module 2: (10T+7P Hours)

Design:, Algorithm paradigms, Divide and conquer - Strassen's algorithm, O(n) median finding algorithm, Dynamic Programming - Matrix Chain Multiplication, Optimal Polygon Triangulation, Optimal Binary Search trees, Floyd-Warshall algorithm, CYK algorithm - greedy - Huffman coding, Kruskal and Prim algorithms, Knapsack - Backtracking - Branch and Bound - Traveling salesman problem.

Module 3: (9T+5P Hours)

Complexity: complexity classes - P, NP, Co-NP, NP-Hard and NP-Complete problems - Cook's theorem-NP-Completeness reductions for Clique - Vertex Cover - Subset Sum - Hamiltonian cycle - TSP - Integer Programming - Approximation algorithms - Vertex cover - TSP - Set Covering and Subset Sum

Module 4: (10T+7P Hours)

Probabilistic algorithms: Pseudo Random Number Generation Methods - Monte Carlo algorithms - Probabilistic counting - Verifying matrix multiplication - Las Vegas algorithms - Randomized Selection and Sorting - Randomized max cut algorithm.

References:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms*, 3/e, Prentice Hall India, 2010
2. R. Motwani and P. Raghavan, *Randomized Algorithms,* Cambridge University Press, 2001
3. A. Levitin, *Introduction to the Design & Analysis of Algorithms,* Pearson Education. 2003

CS4051D CODING THEORY

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1: (9 Hours)

Linear Codes: Review of linear algebra - Linear codes and syndrome decoding. Generator and parity check matrices, Singleton bound, Plotkin bound. Hamming code, Hadamard code.

Module 2: (10 Hours)

Cyclic codes: BCH codes, BCH–key equation and algorithms. Berlekamp's Iterative decoding Algorithm, decoding with Euclid's algorithm, Reed Solomon codes, decoding Reed Solomon codes.

Module 3: (10 Hours)

List decoding: Johnson's bound, Sudan-Guruswami algorithm. Convolutional codes: trellis decoding, Viterbi's algorithm.

Module 4: (10 Hours)

Codes on Graphs: Concept of girth and minimum distance in graph theoretic codes. Expander Graphs and Codes – linear time decoding. Basic expander based construction of list decodable codes. Sipser Spielman algorithm. Bounding results.

References:

1. W. C. Huffman and V. Pless, *Fundamentals of error correcting codes*, Cambridge University Press, 2003.
2. J. H. Van Lint, *An Introduction to Coding Theory,* 2/e, New York: Springer-Verlag, 1992.
3. R. J. McEliece, *The Theory of Information and Coding,* Addison Wesley, 1997.

CS4052D LOGIC FOR COMPUTER SCIENCE

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total Hours: 39T+26P

Module 1: (10T+7P Hours)

Omega regular languages and Buchi automata - properties, complementation, deterministic Buchi-regular languages. Buchi's complementation theorem,

Module 2: (10T+7P Hours)

Linear time temporal logic - Vardi-Wolper construction, model checking using Buchi automata. Introduction to SPIN. Software verification using SPIN.

Module 3: (10T+7P Hours)

Monadic second order logic, equivalence of MSO and Buchi automata, Safra construction.
S2S. Rabin's tree automata theorem (no proof).

Module 4: (9T+5P Hours)

Computation Tree Logic, Binary decision diagrams, SMV model checker. Software verification using SMV.

References:

1. M. Huth and M. Ryan, *Logic in Computer Science: Modeling and Reasoning about Systems*, 2/e, Cambridge University Press, 2005.
2. C. Baler, *Principles of Model Checking*, MIT Press, 2008.
3. E. M. Clerke. Jr, O. Grumberg, and D. Peled, *Model Checking,* MIT Press, 2001.

CS4053D TOPICS IN LOGIC

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (9 Hours)

Logic: Review of compactness and resolution of propositional logic. First order logic: Syntax and semantics, compactness theorem, completeness theorem, Herbrandization, resolution.

Module 2: (10 Hours)

Computability: Undecidability, recursion theorem, Godel's incompleteness theorem, decidability of Presburger arithmetic.

Module 3: (10 Hours)

Finite model theory: Ehrenfeucht Fraisse games, locality arguments, first order inexpressibility results.

Module 4: (10 Hours)

Complexity: Fagin's theorem, logical characterizations of complexity classes P, PH, and PSPACE.

References:

1. C. H. Papadimitriou, *Computational Complexity,* Addison Wesley, 1994
2. L. Libkin, *Elements of finite model theory*, Springer, 2004.
3. H. Ebbinghaus, *Finite model theory*, Springer, 2005.

CS4054D PARAMETERIZED ALGORITHMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Review of complexity classes - P, NP, Co-NP, NP-Hard and NP-complete problems - Cook's Theorem. Strategies for Coping with hard algorithmic problems; Exact exponential algorithms and the notion of fixed-parameter tractability. Parameterizations and Parameterized problems- Satisfiability problem, Vertex cover - An illustrative example, Art of problem Parameterization.

Module 2: (10T+6P Hours)

Algorithmic methods: Data reduction and problem kernels. Depth bounded search trees for Maximum satisfiability, Cluster editing, Vertex cover, 3-Hitting set, Dominating set in Planar graphs.

Module 3: (10T+7P Hours)

Dynamic programming – Set cover, Tree structured variants of set cover and Steiner Trees. Randomized methods in Parameterized algorithms – Simple randomized algorithm for Vertex cover, Feedback Vertex Set, Color coding algorithm for Longest path.

Module 4: (9T+6P Hours)

Path and Tree decomposition – Dynamic Programming on graphs of bounded treewidth – Treewidth and Monadic second-order logic, Graph searching, interval and chordal graphs. Computing treewidth – Balanced separators and separations – FPT approximation algorithm for treewidth.

References:

1. M. Cygan, F. V. Fomin, L. Kowalik, D. Lokshtanov, D. Marx, M. Pilipczuk, M. Pilipczuk, and S. Saurabh, *Parameterized Algorithms*, Springer, June 2015.
2. R. Niedermeier, *Invitation to fixed-parameter algorithms*, Oxford university press, 2006.
3. R. G. Downey and M. R. Fellows**,** *Fundamentals of Parameterized Complexity*, Springer, 2013.

CS4055D PARAMETERIZED COMPLEXITY THEORY

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Fixed Parameter Tractability - Introduction, Parameterized Problems and Fixed-Parameter Tractability, Reductions and Parameterized Intractability - Fixed-parameter Tractable reductions - The class para-NP, and The class XP.

Module 2: (10 Hours)

Parameterized complexity theory – Complexity class W[1] - Concrete parameterized reductions – W[1]-hardness proofs – Further reductions and W[2]-hardness. Lower bounds and the complexity class M[1], lower bounds and linear FPT-reductions.

Module 3: (10 Hours)

Kernelization and Linear Programming Techniques, Tree Decomposition of Graphs, Computing Tree Decompositions, Algorithms on structures of Bounded Tree width. Applications of Courcelle's Theorem - Tree width reductions and Graph Minors

Module 4: (9 Hours)

Machine models, limited nondeterminism, and bounded FPT. Selected case studies: Graph modification problems and Capacitated Vertex cover, Constraint Bipartite vertex cover, Graph coloring, Crossing number, Power dominating set.

References:

1. J. Flum and M. Grohe, *Parameterized Complexity Theory,* Springer, 2006.
2. R. Niedermeier, *Invitation to fixed-parameter algorithms*, Oxford university press, 2006.
3. R. G. Downey and M. R. Fellows**,** *Fundamentals of Parameterized Complexity*, Springer, 2013.

CS4056D INTRODUCTION TO HIGH PERFORMANCE COMPUTING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+5P Hours)

Modern Processors : Stored Program Computer Architecture - Pipelining- Superscalar City - Multicore processors - Multithreaded processors- Vector Processors, Parallel Computers: Taxonomy of parallel computing paradigms- SIMD & MIMD classes of computers, Shared memory computers- Cache coherence- UMA - ccNUMA - Distributed-memory computers - Basics of parallelization - Data Parallelism - Function Parallelism- Parallel Scalability- Factors that limit parallel execution; Homogeneous and heterogeneous parallel computing systems, Supercomputer top500 and Green500 listing

Module 2: (10T+7P Hours)

Homogenous Parallel Computing system, Distributed memory parallel programming with MPI : message passing - introduction to MPI – example - messages and point-to-point communication - collective communication – nonblocking point-to-point communication, Efficient MPI programming : MPI performance tools- communication parameters- Synchronization, serialization, contention- Reducing communication overhead- optimal domain decomposition- Aggregating messages – Non Blocking Vs Asynchronous communication- Collective communication- Understanding intra-node point-to-point communication.

Module 3: (10T+7P Hours)

Shared memory parallel programming with OpenMp : introduction to OpenMp - parallel execution - data scoping- OpenMp work sharing for loops- synchronization - reductions - loop scheduling - tasking - case study: OpenMp- parallel jacobi algorithm- advanced OpenMp wavefront parallelization, Efficient OpenMP programming: Profiling OpenMP programs - Performance pitfalls- Case study: Parallel Sparse matrix-vector multiply.

Module 4: (9T+7P Hours)

Heterogeneous parallel computing system, Accelerators - GPUs, Xeon Phi, FPGAs, Parallel programming using GPU and CUDA, Overview of CUDA C; threads, blocks and grids, warps, different GPU memories, Kernel-Based Parallel Programming, Case studies: vector addition, vector-vector multiplication, matrix-matrix multiplication, Xeon phi and its architecture, parallel programming using Xeon phi, Sample programs

References:

1. G. Hager and G. Wellein, *Introduction to High Performance Computing for Scientists and Engineers*, Chapman & Hall / CRC Computational Science series, 2011.
2. D. Kirk and W. Hwu, *Programming Massively Parallel Processors - A Hands-on Approach*, 3/e, Morgan Kaufmann, 2017
3. M. J. Quinn, *Parallel Programming in C with MPI and OpenMP*, McGraw-Hill, 2003.

CS4057D EMBEDDED SYSTEMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+5P Hours)

Definition of Embedded System, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, applications of embedded systems.automotive embedded system, mobile phones, washing machine, artificial pacemaker, trends in embedded software development

Module 2: (10T+7P Hours)

Characteristics and Quality Attributes of Embedded Systems. Core of the Embedded System: General Purpose and Domain Specific Processors, Microcontrollers, DSPs, FPGAs, ASICs, PLDs, Commercial Off-The-Shelf Components (COTS), Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Reset Circuit, Brownout Protection Circuit, Real Time Clock, Watchdog Timer

Module 3: (10T+7P Hours)

Software engineering practices in the embedded software development process, embedded software development environments, development tools for target processors, real-time embedded software. RTOS, GPOS Vs RTOS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Shared Memory, Message Passing, Remote Procedure Call and Sockets, Device Drivers, How to Choose an RTOS

Module 4: (9T+7P Hours)

Embedded Software Development Tools, Host and target machines – Linkers / Locators for Embedded Software – Debugging techniques – Instruction set simulators Laboratory tools – Practical example – Source code. Recent trends in Embedded Systems.

References:

1. S. Heath, *Embedded System Design*, 2/e, Elsevier, 2004.
2. D. E. Simon, *An Embedded Software Primer*, Pearson Education, 2010
3. DreamTech Software Team, *Programming of Embedded Systems*, Wiley DreamTech, 2002.

CS4058D COMPUTATIONAL GEOMETRY

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+10P Hours)

Introduction to Computational Geometry, its applications. Preliminaries of asymptotic analysis and the notations to represent asymptotic complexity, Example of a geometric problem and its complexity analysis. Art Gallery problem and its associated theorems, Triangulation of a polygon and its theory, Area of a polygon. Polygon partitioning, Monotone partitioning, Trapezoidalization, Plane sweep, Partitioning to monotone mountains, Linear time triangulation. Introduction to Computational Geometric Algorithms Library (CGAL) and openGL and coding of simple programs with visualization using QT.

Module 2: (10T+6P Hours)

Convex hull in two dimensions, Algorithms for convex hull with their complexity analysis: Extreme points, Extreme edges, Gift wrapping, Quickhull, Graham's algorithm, Incremental algorithm, Divide and conquer. Applications of convex hull.hard Implement Convex Hull algorithms and one application using CGAL & visualization using QT**.**

Module 3: (10T+5P Hours)

Voronoi diagram: Basic concepts, Definitions, Properties, Algorithm for construction of Voronoi diagram with its complexity analysis. Delaunay triangulation : Preliminaries and properties. Medial axis transform and its properties. Applications of Voronoi Diagram / Delaunay triangulation / Medial axis transform: Facility location, Reconstruction problem and its algorithms Implement one application of Voronoi diagram/ Delaunay triangulation using CGAL & visualization using QT.

Module 4: (9T+5P Hours)

Arrangements, Incremental algorithm, Voronoi diagram, Delaunay triangulation and convex hull in three dimensions and their applications. Implement one application of 3D Voronoi diagram/ 3D Delaunay triangulation using CGAL & visualization using QGL Viewer.

References:

1. J. O'Rourke, *Computational Geometry in C*, 2/e, Cambridge University Press, 1998.
2. M. de Berg, M. van Kreveld, M. Overmars, and O. Schwarzkopf, *Computational Geometry: Algorithms and Applications*, 2/e (revised), Springer-Verlag,2000.
3. F. P. Preparata and M. I. Shamos, *Computational Geometry: An Introduction*, Springer-Verlag, 1985.

CS4059D TOPICS IN COMPUTATIONAL GEOMETRY

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Binary space partitions : Definition, basic concepts, construction using randomized algorithm, theorems, . CGAL implementation of Painter's algorithm

Module 2: (10 Hours)

Robot motion planning: Workspace and configuration space, Point robot, Minkowski sums, Translational motion planning, Quadtrees: Uniform and non-uniform meshes, Quadtrees for point sets, Quadtrees to meshes.

Module 3: (10 Hours)

Visibility Graphs: Shortest paths for a point robot, Visibility graphs, Shortest paths for a translating polygonal robot.

Module 4: (9 Hours)

Interval Trees, Priority Search Trees, Segment Trees, Partition trees, Multi-level partition trees. Simplex Range Searching.

References:

1. M. de Berg, M. van Kreveld, M. Overmars, and O. Schwarzkopf, *Computational Geometry: Algorithms and Applications*, 2/e(revised), Springer-Verlag, 2000.
2. S. L. Devadoss and J. O'Rourke, *Discrete and Computational Geometry*, Princeton University Press, 2011.
3. K. Mulmuley, *Computational Geometry: An Introduction through Randomized Algorithms*, Prentice-Hall, 1994.

CS4060D INTRODUCTION TO DATA SCIENCE

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+6P Hours)

Introduction to Data Science, Review of Basic Concepts in Statistics, Probability and Linear Algebra, Data Modelling: Supervised and Unsupervised Learning - Linear Regression, k-Nearest Neighbours (k-NN), k-Means Clustering.

Module 2: (10T+8P Hours)

Exploratory Data Analysis, The Data Science process, Introduction to R programming, Extracting Meaning From Data- Feature Generation, Feature Selection algorithms, Advanced supervised learning approaches - Linear Support Vector Machines, Decision Trees, Random Forests.

Module 3: (10T+6P Hours)

Recommendation Systems - Algorithmic Ingredients, Dimensionality Reduction, Singular Value Decomposition, Principal Component Analysis, Data Visualization, Ideas and Tools for Data Visualization.

Module 3: (9T+6P Hours)

Working with Big Data – Social Networks as Graphs, Clustering of graphs, Direct discovery of communities in graphs, Partitioning of graphs, Emerging Trends in Data Science.

References:

1. C. O’Neil and R. Schutt, *Doing Data Science: Straight Talk from the Frontline* , O’Reilly, 2014.
2. J. Leskovec, A. Rajaraman, and J. D. Ullman, *Mining of Massive Datasets*, V 2.1, Cambridge University Press, 2014.
3. M. J. Zaki and W. Meira Jr, *Data Mining and Analysis: Fundamental Concepts and Algorithms*, Cambridge University Press, 2014.
4. A. Blum, J. E. Hopcroft and R. Kannan, *Foundations of Data Science*, e-book, 2013
5. J. Han, M. Kamber, and J. Pei, *Data Mining: Concepts and Techniques*, 3/e, Elsevier, 2012.

CS4061D TOPICS IN DATA ANALYTICS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Introduction to Data Analytics- Revision of Mathematical Basics - Probability, Statistics, Linear Algebra and Calculus - Data Preparation and Cleansing - Descriptive Statistics- Probability Distributions- Inferential Statistics through hypothesis test- Regression and ANOVA

Module 2: (10T+7P Hours)

Machine Learning: Introduction and Concepts- Differentiating algorithmic and model based frameworks - Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification- Supervised Learning with Regression and Classification techniques -Bias-Variance Dichotomy, Model Validation Approaches, Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis, Regression and Classification Trees, Support Vector Machines

Module 3: (10T+6P Hours)

Ensemble Methods: Random Forest , Neural Networks, Deep learning, Unsupervised Learning and Challenges for Big Data Analytics – Clustering Associative Rule Mining, Challenges for big data analytics Prescriptive analytics - Creating data for analytics through designed experiments, Creating data for analytics through Active learning, Creating data for analytics through reinforcement learning

Module 4: (9T+6P Hours)

Massive Data Analytics - Social Network Analytics - Security and Privacy Issues

References:

1. T. Hastie, R. Tibshirani, and J. Friedman, *The elements of statistical learning*, 2/e, Springer, 2009.
2. D. C. Montgomery and G. C. Runger, *Applied statistics and probability for engineers,* John Wiley & Sons, 2010.
3. K. P. Murphy, *Machine Learning, a probabilistic perspective*, MIT Press Cambridge, Massachusetts, 2012
4. A. Smola and S. V. N. Vishwanathan, *Introduction to Machine Learning*, Cambridge University Press, 2008.
5. J. E. Hopcroft and R. Kannan, *Foundations of Data Science*, e-book, 2013

CS4062D INTRODUCTION TO INFORMATION SECURITY

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Introduction to Information Security - CIA triad - Cyber Attacks - Defence Strategies and Techniques - Secure Software Design Principles, Access Control and Authentication, Biometric Authentication - Malwares Viruses and Worms - Firewalls and Intrusion Detection System

Module 2: (15 Hours)

Cryptography- Basics of Cryptography - Elementary Substitution and Transposition Ciphers - Hill Cipher, Vigenere Cipher - Symmetric Cipher - DES - Kerckhoff's principle - Asymmetric Cipher - RSA - Cryptographic Hashing - SHA1 - Digital Signature

Module 3: (14 Hours)

Introduction to security of information storage, processing, and transmission.
Information Security Management - The ISO Standards relating to Information Security - Other Information Security Management Frameworks - Security Policies - Security Controls - The Risk Management Process - Regulations and legal frameworks

References:

1. B. Menezes, *Network security and Cryptography*, Cengage Learning India, 2010.
2. B. A. Forouzan and D. Mukhopadhyay, *Cryptography and Network Security,* 2/e, Tata McGraw Hill, 2010.

CS4063D TOPICS IN CRYPTOGRAPHY

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (9T Hours)

Review of classical cryptography - Historical ciphers and their cryptanalysis. Principles of Modern Cryptography - Formal definitions, precise assumptions, proof of security. Provable security.
Perfectly secret encryption - The one time pad. Limitations of perfect secrecy. Shannon's Theorem.
Practical construction of stream ciphers.

Module 2: (16 T+16 P Hours)

Private-Key Encryption - Computational Security and Computationally Secure Encryption - Constructing Secure Encryption Schemes - Linear and Differential Cryptanalysis.
Message Authentication Codes - Constructing Secure MAC - Authenticated Encryption.
Hash functions - Generic attacks and proof of security.
Practical block ciphers and hash functions.

Module 3: (14 T+10 P Hours)

Public-Key Encryption - Review of number theory concepts - Primality Testing - Solovay Strassen, Miller Rabin tests. Algorithms for factoring. Algorithms for computing discrete logarithms.
Review of RSA - Attacks on RSA. Security of Public Key Encryption systems against chosen plaintext and chosen ciphertext attacks. Introduction to Elliptic Curve Cryptosystems, Homomorphic Encryption, Threshold Encryption.

References:

1. J. Katz and Y. Lindell, *Introduction to Modern Cryptography, 2/e, CRC Press, 2014*
2. H. Delfs and H. Knebl, *Introduction to Cryptography Principles and Applications*, Springer, 2002
3. D. R. Stinson, *Cryptography Theory and Practice, 3/e*, CRC Press, 2006

CS4064D PROGRAM ANALYSIS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (9T+7P Hours)

Approaches to Program Analysis - Data-flow Analysis, Constraint based analysis, Abstract Interpretation, Type and effect systems

Module 2: (10T+6P Hours)

Data-flow Analysis: Program Representations - Control Flow Graph, Analysis for computing : available expressions, reaching definitions, live variables. Applications of analysis in code improving transformations

Module 3: (10T+7P Hours)

Data-flow Analysis Framework: Lattice theoretic modeling - Monotone frameworks, Distributive frameworks. Constant Propagation framework, Iterative algorithm for monotone frameworks - Maximal Fixed Point solution, Meet Over All Paths solution.

Module 4: (10T+6P Hours)

Type and effect Systems - control flow analysis, Introduction to inter procedural analysis and shape analysis.

References:

1. F. Nielsen, H. R. Nielson, and C. Hankin, *Principles of Program Analysis*, Springer 1999.
2. A. V. Aho, M. S. Lam, R. Sethi, and J. D. Ullman, *Compilers: Principles, Techniques, and Tools*, Pearson Education, 2007
3. S. Muchnick, *Advanced Compiler Design and Implementation,* Morgan Kaufmann, 1997

CS4065D FORMAL SEMANTICS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (9T+7P Hours)

Preliminaries, Mathematical foundations. Methods for Semantics Specification - Introduction to Operational, Denotational, and Axiomatic semantics.

Module 2: (10T+6P Hours)

Operational Semantics - Natural semantics, Structural operational semantics. Semantics of a simple imperative language - operational semantics of expressions, assignments, conditional and looping constructs.

Module 3: (10T+7P Hours)

Denotational Semantics: Semantic functions, Semantics of expressions, assignments, conditional and looping constructs. Fixed points, existence of fixed points.

Module 4: (10T+6P Hours)

Axiomatic Program Verification - Partial Correctness assertions, Inference systems. Extensions of the axiomatic system – Total correctness assertions.

References:

1. F. Nielson and H. R. Nielson, *Semantics with Applications: A Formal Introduction*, John Wiley & Sons Inc., 1992.
2. G. Winskel, *The Formal Semantics of Programming Languages - An Introduction,* MIT Press, Cambridge, MA, 1994.
3. D. Schmidt, *Denotational Semantics: A Methodology for Language Development*., Kansas State University, 2011

CS4066D ALGORITHMIC DECISION MAKING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (13T+10P Hours)

Probability Theory, Bayesian Inference, Bayesian Networks, Modeling and Reasoning with Bayesian Networks, Applications of Bayesian Networks.
Decision Trees (basics), Influence Diagrams, Modeling and solving Influence Diagrams.
Bayesian Networks and Influence diagrams in dynamic decision making.

Module 2: (13T+10P Hours)

Parameter Learning - Learning a Single Parameter, Beta Density Function, Learning Parameters in a Bayesian Network.
Structure Learning- Schema and Procedure for learning Structure, Model Averaging, Probabilistic Model selection, Hidden Variable DAG models.

Module 3: (13T+6P Hours)

Reinforcement Learning - Introduction, Markov Property, Markov Decision Processes,Value Functions.
Dynamic Programming in Policy Evaluation, Policy Improvement, Policy Iteration and Value Iteration Methods

References:

1. R. E. Neapolitan, *Learning Bayesian Networks,* Pearson, 2003.
2. A. Darwiche, *Modeling and Reasoning with Bayesian Networks,* Cambridge University Press, 2009.
3. R. S. Sutton and A. G. Barto, *Reinforcement Learning: An Introduction*, MIT Press, 1998.
4. M. J. Kochenderfer, *Decision Making Under Uncertainty, Theory and Application*, MIT Press, 2015.

CS4067D FOUNDATIONS OF PROGRAMMING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

Programming methodology. Specification, Design, Coding. Separation of concerns such as correctness, efficiency, and maintainability. Fundamental concepts and constructs in programming languages.

Module 2: (10T+7P Hours)

Procedural Abstraction: Expressions - Naming and Environment - Combinators - Evaluation - Procedures - Substitution model - Conditional expression and predicates. Linear Recursion and Iteration - Tree recursion. Abstractions with Higher Order Procedures - Procedures as arguments - Constructing procedures – examples.

Module 3: (10T+6P Hours)

Data Abstraction: Hierarchical Data and Closure property - Symbolic Data - Data Directed Programming - Generic Operators - Combining data of different types

Module 4: (9T+6P Hours)

Modular design: Modularity, Objects, and State: Local state - assignment, environment model for evaluation - frames, Modeling with mutable data. Encapsulation, inheritance, and polymorphism.

References:

1. H. Abelson and G. J. Sussman, *Structure and Interpretation of Computer Programs,* 2/e, Universities Press, 2005.
2. Companion Site to the Textbook. Available at http://mitpress.mit.edu/sicp/ Accessed on December 1, 2010.
3. T. C. Lethbridge and R. Laganiere, *Object Oriented Software Engineering,* 1/e, Tata McGraw Hill, 2004.

CS4068D DNA COMPUTING MODELS

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Introduction, Theoretical Computer Science: Graphs, Finite State Automata, Computability, Formal Grammars, Combinatorial Logic, Computational Complexity, Molecular Biology: DNA, Gene, Gene expression.

Module 2: (10 Hours)

Word Design for DNA Computing: Constraints, DNA Languages, DNA Code Constructions and Bounds, In Vitro Random Selection.

Module 3: (10 Hours)

Non-Autonomous DNA Models: Seminal Work, Filtering Models, Sticker Systems, Splicing Systems

Module 4: (9 Hours)

Autonomous DNA Models: Algorithmic Self-Assembly, Finite State Automaton Models, DNA Hairpin Model, Computational Models

References:

1. Z. Ignatova, I. Martínez-Pérez, and K. H. Zimmermann, *DNA Computing Models,* Springer, 2008.
2. G. Paun, G. Rozenberg, and A. Salomaa, *DNA Computing: New Computing Paradigms***,** Springer Science & Business Media, 2005.

CS4069D HASHING TECHNIQUES FOR BIG DATA

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Low dimensional index structures; Hashing - Static Hashing, Dynamic Hashing, Locality Sensitive Hashing, Multidimensional Hashing, Space Filling Curves.
Memory based index structures - Binary Search Tree, Quad Tree, K-D Tree, Range Tree, Voronoi Diagram, Tries, Suffix Trees.
Disk based index structures - B Tree, B+ Tree, K-D B Tree, General Framework, R Tree, R* Tree, R+ Tree, Hilbert R Tree, SS Tree, SR Tree, P Tree, Bulk Loading; Distances:

Module 2: (10 Hours)

Distance functions - Metric Spaces, L_p Norm, Quadratic Form Distance, Cosine Similarity, Statistical Distance measures, Distance between set of objects, Earth Mover's Distance, Edit Distance.
Distance based Structures - Triangular Inequality, VP Tree, GH tree, GNAT, M Tree, SA Tree, AESA, Linear AESA, AESA for vector spaces.

Module 3: (10 Hours)

High-Dimensional Spaces- Analysis of Search for High-Dimensional Data, Expected Nearest Neighbour Distance, Expected Number of Page Accesses, Curse of Dimensionality. High-Dimensionality Structures - X Tree, Pyramid Technique, MinMAx, VA File, A Tree, IQ Tree
Dimensionality Reduction Techniques: Properties Useful for Similarity search, Quality Measures, Embedding, Singular Value Decomposition, Principal Component Analysis, Multi-Dimensional Scaling, IsoMap, FastMap, Embedding Methods, Bounds of Distortion.

Module 4: (9 Hours)

Data Representation Techniques - Discrete Fourier Transform, Discrete Cosine Transform, Discrete Wavelet Transform, V-Optimal Histogram
Data-independent Hashing, Data-Dependent Hashing - Unsupervised Hashing, Supervised Hashing, Ranking-Based Hashing, Multimodal Hashing, Deep Hashing, Online Hashing, Quantization for Hashing, Distributed Hashing.

References:

1. A. Bhattacharya, *Fundamentals of Database Indexing and Searching*, 1/e, Chapman and Hall/CRC, 2016.
2. H. Samet, *The Design and Analysis of Spatial Data Structures*, 1/e, Addison-Wesley, 1989
3. T. Teofili, *Deep Learning for Search*, 1/e, Manning Publications, 2018.

CS4070D TOPICS IN COMPUTER NETWORKS

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Networking basics, Gigabit Ethernet, Spanning Tree Algorithm and Redundancy, VLAN, Software-Defined Networking, Virtual Private Networks, WiFi, WiMax, LTE, 5G, ATM, Optical Networking, Backbone Network Design

Module 2: (10 Hours)

IP version 6, Implications of IPv6, MPLS, Large Scale routing- BGP. Routing in Mobile adhoc networks, SCTP, DCCP, Newer TCP Implementations - Highspeed TCP; TCP Vegas; FAST TCP; TCP Westwood; TCP Illinois; Compound TCP; TCP Veno; TCP Hybla; DCTCP; H-TCP; TCP CUBIC; TCP BBR

Module 3: (10 Hours)

Queuing and scheduling, Queuing and real time traffic, Traffic management, Queuing Disciplines - Priority Queuing; Fair Queuing; Hierarchical Queuing; Hierarchical Weighted Fair Queuing; Token Bucket Filters

Module 4: (9 Hours)

Traffic engineering, Quality of Service - Net Neutrality; Real-time Traffic; Integrated Services / RSVP; Global IP Multicast; RSVP; Differentiated Services; RED with In and Out; NSIS; Real-time Transport Protocol (RTP); Multi-Protocol Label Switching (MPLS)
SNMP and multimedia over Internet, Enterprise Network Security

References:

1. N. F. Mir, *Computer and Communication Networks*, 1/e, Prentice Hall, 2006.
2. W. Stallings, *Data and Computer Communications*, 10/e, Pearson Education India, 2013..
3. P. Loshin, *TCP/IP Clearly Explained*, 4/e, Morgan Kaufmann, 2002.

CS4071D NETWORK ANALYSIS IN BIOINFORMATICS

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Hours)

Introduction to molecular biology- DNA,RNA,Protein, Gene, Cell Metabolism, Systems biology- Biological networks- Network representation- Network types: PPI, Genetic interaction networks, Metabolic networks, Gene/transcriptional regulatory networks, Cell signaling networks, Pathways, Phylogenetic trees

Module 2: (10 Hours)

Introduction to network science- Network characteristics- Shortest paths- Network flows- Centrality measures- Network communities and modules- Network motifs- Network clustering- Spectral clustering- Subgraphs-Network Diffusion- Random walk models

Module 3: (10 Hours)

Heterogeneous Information Networks- Definition- Properties- Meta paths- HIN algorithms- Clustering & classification in HIN- Similarity search- Relationship mining
Multilayer networks- Data collection and preprocessing- Visualization- Community detection- Information diffusion- Edge pattern

Module 4: (9 Hours)

Biological network analysis in R- Manipulation and visualization of network data- igraph package- Implementation of centrality measures- Basics of graph modeling in R- Bioconductor- BioNet package- Other network analysis tools (eg. Cytoscape)

References:

1. B. Alberts et al., *Molecular Biology of the Cell,* Garland Science Publishers, 2014
2. B. Junker and F. Schreiber, *Analysis of Biological Networks,* Wiley Publishers, 2007
3. A. L. Barabasi, *Network Science*, Cambridge University Press, 2016
4. Y. Sun and J. Han, *Mining Heterogeneous Information Networks- Principles & Methodologies,* Morgan & Claypool Publishers, 2012
5. M. E. Dickison et al, *Multilayer Social Networks*, Cambridge University Press, 2016
6. E. D. Kolaczyk and G. Csardi, *Statistical Analysis of Network Data with R*, Springer-Verlag, New York, 2014

CS4089D TERM PAPER

Prerequisites: NIL

L	T	P	C
0	0	8	3

The student is required to conduct a detailed literature survey in an area of research in the field of computing and compile a report of her/his study in the area. The student may include any observations from her/his own experimentation in the area in the report.

References:

1. G. J. Alred, C. T. Brusaw, and W. E. Oliu, *The Handbook of Technical Writing*, 11/e, Bedford/St. Martins, 2015.
2. P. A. Laplante, *Technical Writing: A practical guide for engineers and scientists,* CRC Press, 2011.

CS3007D OBJECT ORIENTED SYSTEMS

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T+26P

Module 1: (10T+7P Hours)

An Overview of Object Oriented Systems Development- Object Basics- Object Oriented System Development Life Cycle - Object Oriented Methodologies- Unified Modelling Language

Module 2: (10T+7P Hours)

Use Case based Object Oriented Analysis - Classification - Identification of Object Relationships and Methods. Object Oriented Design - Principles - Classes - Patterns - Designing Data Store , User Interface

Module 3: (10T+6P Hours)

Object Oriented Architecture - OOAD Testing and Quality Strategies - Object Oriented Metrics

Module 4: (9T+6P Hours)

OOAD Implementation Strategies - Pragmatics - Management Planning , Release Management, Handling Changes, Reuse

References:

1. A. Bahrami, *Object Oriented Systems Development*, 1/e, McGraw-Hill, 2000
2. G. Booch, R. A. Maksimchuk, M. W. Engle, B. J. Young, and J. Conallen, *Object-Oriented Analysis and Design with Applications*, 3/e, The Addison Wesley Object Technology Series.
3. B. D. McLaughlin, G. Pollice, and D. West, *Head First Object-Oriented Analysis and Design*, 1/e, O'Reilly .

CS4072D ADVANCED PROGRAMMING AND DATA STRUCTURES FOR ENGINEERS

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

The course is designed for students from non CS departments to gain a primary understanding of data structures and algorithm design.

Module 1: (13 Hours)

Introduction to time complexity analysis, asymptotic notation and solution to simple recurrences, analysis of binary search, quicksort, merge sort and heap sort algorithms.

Module 2: (13 Hours)

Pointers and linked lists - linked list, stack, queue, binary search tree, worst and average case analysis, preorder, inorder and postorder traversals, evaluation of arithmetic expressions, complexity analysis.

Module 3: (13 Hours)

Algorithm design paradigms, divide and conquer - dynamic programming and greedy algorithms, Introduction to NP completeness.

References:

1. A. V. Aho, J. E. Hopcroft, and J. D. Ullman, *Data Structures and Algorithms*, Addison-Wesley, 1983.
2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms,* 3/e, MIT Press, 2009.
3. E. Horowitz, S. Sahni, and D. Mehta, *Fundamentals of Data Structures in C++*, 2/e, Universities Press, 2008.

CS4073D COMPUTING SYSTEMS FOR ENGINEERS

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

The course is designed for students from non CS departments to gain a primary understanding of computer hardware design and systems software.

Module 1: (13 Hours)

Arithmetic Logic Unit: Gates and flip flop, number systems - two's complement addition, comparator circuits, design of the Hack processor's ALU.

Memory design: multiplexers and demultiplexers, D-flip flops, design of the Hack processor's memory

Module 2: (13 Hours)

Control unit - system architecture, Hack keyboard and memory interface, design of the Hack
Hack machine instruction set. Hack assembly language, simple programming exercises on the
Hack platform.

Module 3: (13 Hours)

Introduction to systems software - compilers, and operating systems. Simple examples of high level language translation. OS functions and interfaces.

References:

1. N. Nisan and S. Schocken, *The elements of computing systems: Building a modern computer from first principles*, MIT Press, 2008.
2. C. Petzold, *Code: The hidden language of computer hardware and software*, Microsoft Press, 2000.

CS3091D COMPILER LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Introduction to the use of the Flex and Bison. Syntax directed translation scheme in bison. Code generation from abstract syntax tree, run time activation records, dynamic memory allocation.

Practical (39 Hours)

1. Generation of lexical analyzer using Flex.
2. Parsing using Bison.
3. Symbol table implementation.
4. Type checking using syntax directed translation scheme of Bison.
5. Intermediate code generation - abstract syntax tree representation of programs.
6. Run time stack implementation for subroutine invocations.
7. Register allocation and code generation.

References:

1. W. Appel, *Modern Compiler Implementation in C*, Cambridge University Press, 1998.
2. V. Aho, M. S. Lam, R. Sethi, and J. D. Ullman, *Compilers- Principles, Techniques & Tools*, 2/e, Pearson Education, 2007.
3. D. Grune, K. V. Reeuwijk, H. E. Bal, C. J. H. Jacobs, and K. Langendoen, *Modern Compiler Design*, 2/e, Pearson Education, 2007.

CS3092D OPERATING SYSTEMS LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

System programming fundamentals and system call interface. System calls for file system, process management and process synchronization.

Practical (39 Hours)

1. Loading executable programs into memory, implement file system calls Read(), Write(), Open (), Seek() and Close().
2. Multiprogramming-Memory management- Implementation of Fork(), Wait(), Exec() and Exit() System calls.
3. IPC system call implementation - Signal-Wait, Semaphores.
4. Demand paging and swapping -implementation.
5. Shell and System utilities - implementation.
6. Implementation Low level routines - disk and terminal driver, timer interrupt handler and scheduler.

References:

1. G. J. Nutt, *Operating Systems*, 3/e, Pearson Education, 2004.
2. D. P. Bovet and M. Cesati , *Understanding the Linux Kernel,* 3/e, O'Reilly Media, 2005
3. C. Crowley, *Operating Systems: A design oriented approach*, 1/e, Mc. Graw Hill, 2006.

CS3093D NETWORKS LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Introduction, Overview of Unix Programming Environment, Unix Programing Tools, Introduction to Computer Networking and TCP/IP, Introduction to Socket Programming, TCP Sockets and Concurrent Servers, Threads, I/O Multiplexing and Socket Options, UDP Sockets and Name and Address Conversions, Daemon Processes and Inetd Superserver, Advanced I/O and Timeouts, Non-blocking Sockets, Unix Domain Sockets, Broadcasting, Multicasting, Advanced UDP Sockets, Ioctl Operations. Introduction to open source firewall packages. Introduction to network emulators and simulators.

Practical (39 Hours)

1. Implementation of basic Client Server program using TCP Socket (Eg. Day time server and clent).
2. Implementation of basic Client Server program using UDP Socket.
3. Implementing a program with TCP Server and UDP Client.
4. Implementation of TCP Client Server program with concurrent connection from clients.
5. Implementing fully concurrent application with a TCP server acting as a directory server and client programs allowing concurrent connection and message transfer (Eg. Chat system).
6. Fully decentralized application like a Peer to Peer system. This program is to implement without a designated Server as in the case of experiment 5.
7. Experiments with open source firewall/proxy packages like iptables, ufw, squid etc.
8. Experiments with Emulator like Mininet / Netkit / Emulab
9. Experiments with Simulator like NS2,/NCTUns .

References:

1. W. R. Stevens, *Unix Network Programming – Networking APIs: Sockets and XTI,* 2/e, Volume 1, Pearson Education, 2004.
2. W. W. Gay, *Linux Socket Programming by Example,* 1/e, Que Press, 2000.

CS3094D SYSTEMS PROGRAMMING LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Basics of shell programming. Unix system call interface, semaphores, shared memory, Posix threads, thread and process synchronization.

Practical (39 Hours)

1. Unix/Linux shell programming exercises.
2. Inter-process communication and process synchronization, semaphores and shared memory - solution to dining philosophers problem, reader-writer problem.
3. Signal handling, wait and kill operations.
4. Threads for multiprogramming - posix threads, reader- writer problem using threads.
5. Software synchronization - Peterson’s algorithm.
6. Dynamic memory allocation - variable cell allocation, Buddy system allocation.

References:

1. B. W. Kernighan and R. Pike, *The Unix Programming Environment*, Prentice Hall, 1983.
2. W. R. Stevens, *Advanced Programming in the Unix Environment*, 3/e, Addison Wesley, 2013.

CS3095D DATABASE MANAGEMENT SYSTEMS LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Study of Postgresql, PL/SQL programming and JDBC. Concepts of views, scripts, triggers and transactions, SQL DBA, PHP, Eclipse. Servlets.

Practical (39 Hours)

Laboratory exercises for the following:

1. Defining schemas for applications
2. Creation of databases
3. Writing SQL and PL/SQL queries, to retrieve information from the databases
4. Use of host languages
5. Interface with embedded SQL
6. Use of forms & report writing packages available with the chosen RDBMS product preferably Postgres
7. SQL Programming exercises on using scripting languages like PHP
8. Giving web interfaces for back end database applications.
9. Programming in Java for connecting Postgresql databases using JDBC.
10. Creating web page interfaces for database applications using servlets.

References:

1. A. Silberschatz, H. Korth, and S. Sudarshan, *Database System Concepts*, 5/e, McGraw Hill, 2005.
2. R. Elmasri and S. Navathe, *Fundamentals of Database Systems*, 5/e, Addison Wesley, 2007.
3. J. D. Ullman and J. Widom, *A First Course in Database Systems*, 3/e, India: Pearson, 2016.

CS4090D COMPUTER SECURITY LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Review of Computer Networks - Associated vulnerabilities and prevention mechanisms.
Review of Cryptographic Algorithms - Secret and Public Key Cryptography, Key Management, Hashing, Signature
Review of Software Vulnerabilities - Buffer Overflow, Format String, Race Conditions
Review of Internet Vulnerabilities - DoS, SQL injection, XSS

Practical (39 Hours)

Simulating attacks based on vulnerabilities in Network, Web and Software (includes attacks like buffer overflow, format string, SQL injection, XSS)
Implementation of cryptographic primitives and solutions using cryptographic libraries in Python / Java
Deploying and using tools like Wireshark, Webgoat, Nmap, Metasploit, Ettercap

References:

1. Michael Gregg, *Build Your Own Security Lab,* Wiley India, 2008
2. B. Menezes, *Network security and Cryptography*, Cengage Learning India, 2010.

CS4091D DATA ANALYTICS LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)
Supervised and Unsupervised learning methods, Dimensionality reduction methods, Data independent and data dependent hashing methods, Unsupervised Hashing, Supervised Hashing, Ranking-Based Hashing, Multi-Modal Hashing, Deep Hashing, Online Hashing, Quantization for Hashing, Distributed Hashing, Hadoop and MapReduce.

Practical (39 Hours)
1. Generative model linear classification
2. Discriminative model linear classification
3. Clustering
4. Dimensionality reduction
5. Approximate nearest neighbour search
6. Supervised hashing
7. Unsupervised hashing
8. Deep hashing
9. Distributed Hashing

References:

1. W. McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython*, 2/e, Shroff/ O'Reilly Reprints, 2017.
2. J. VanderPlas, *Python Data Science Handbook: Essential Tools for Working with Data*, 1/e, O'Reilly Media, 2016
3. I. Goodfellow, Y. Bengio, and A. Courville, *Deep Learning*, 1/e, MIT Press, 2017.

CS4092D MACHINE LEARNING LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Fundamentals of Machine Learning, Bayes classifier, Parameter Estimation, Discriminant Functions, SVM, ANN.

Practical (39 Hours)

1. Bayes Classifier.
2. Parameter Estimation(MLE and Non-parametric Estimation).
3. Linear Data Analysis Methods(LDA,PCA,Regression).
4. Support Vector Machines.
5. KNN Classifier.
6. Decision Trees and Random Forest.
7. Artificial Neural Network and Deep Learning.

References:

1. R. O. Duda, P. E. Hart, and D. G. Stork, *Pattern Classification* , John-Wiley, 2004.
2. C. M. Bishop, *Pattern Recognition and Machine Learning,* Springer, 2006.
3. Yuxi(Hayden) Liu, *Python Machine Learning by Example*, Packt, 2017.

CS4093D IMAGE PROCESSING LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

An introduction to digital images- sampling, quantization. Basic image processing, arithmetic processing. Image enhancement and point operation. Image enhancement and spatial operation. Color images and models models. Frequency domain operations. Image Analysis

Practical (39 Hours)

1. Image resampling
2. Basic image processing, arithmetic processing
3. Image enhancement and point operation- Linear point operation, clipping, thresholding, negation, non-linear mapping, intensity slicing, image histogram, histogram equalization.
4. Image enhancement and spatial operation- Convolution, correlation, linear filtering, edge detection.
5. Color image processing - color models, color enhancement, color thresholding.
6. Frequency domain operations- fourier transform, freq domain filtering
7. Image analysis after basic image processing algorithms.

References:

1. R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, Addison Wesley, 2007.
2. A. K. Jain, *Fundamentals of Digital Image Processing*, Prentice Hall, Englewood Cliffs, 2002.

CS4094D ADVANCED COMPUTER NETWORKS LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Review of socket programming basics, Introduction to ns-3, Introduction to mininet, Introduction to netkit, Software defined networking, Introduction to Linux IP networking

Practical (39 Hours)

1. A Single TCP Sender
2. Two TCP Senders Competing
3. TCP Loss Events and Synchronized Losses
4. TCP Reno versus TCP Vegas
5. TCP Competition: Reno vs Vegas
6. TCP Competition: Reno vs BBR
7. Wireless Simulation
8. Multiple Switches in a Line
9. IP Routers in a Line
10. IP Routers With Simple Distance-Vector Implementation
11. Linux Traffic Control (tc)
12. OpenFlow and the POX Controller
13. Implementation and Modification of the Linux Protocol Stack

References:

1. T. Issariyakul, *Introduction to Network Simulator NS2*, 2/e, Springer, 2012.
2. J. Liebeherr and M. E. Zarki, *Mastering Networks: An Internet Lab Manual*, 1/e, USA, Addison-Wesley Longman Publishing Co., 2003.
3. C. Benvenuti, *Understanding The Linux Network Internals*, 1/e, Om Books, 2006.

CS4096D SOFTWARE ENGINEERING LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Introductory Lectures on the use of appropriate tools is to be given.
Peer review discussions of deliverables will also be done in theory sessions.

Practical (39 Hours)

Objective is to develop a significant software product using sound software engineering principles by small student groups. Choice of appropriate methodology and standard tools are also expected. The lab will have deliverables at each milestone of development.

1. Problem Statement / Product Specification
2. Project Plan – Project Management Tool to be identified and Estimation and Costing to be done.
3. Requirements Document – Specification Tool choice to be justified - In class Review
4. Design Document – Choice of Methodology to be justified - In class Review
5. Code and Test Report – Peer review documents of standards adherence to be provided
6. Demo – Integrated Product or Solution to the problem
7. Review of the process and analysis of variation from initial plan and estimation.

These steps may be replaced by Agile Methodologies and associated tool set like Trello, Git, Docker, CircleCi, Heroku etc. depending on the kind of project and availability of committed customers.

References:

1. R. S. Pressman, *Software Engineering: A Practitioner's Approach,* 6/e, McGraw Hill, 2008.
2. T. C. Lethbridge and R. Laganiere, *Object Oriented Software Engineering,* 1/e, Tata McGraw Hill, 2004.
3. K. Beck, *Extreme Programming,* 2/e*,* Pearson Education, 2006.
4. J Knapp, *SPRINT*, Bantam Press, 2016.

CS4097D OBJECT ORIENTED SYSTEMS LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Procedural vs. Object oriented approaches – Concept of Abstraction - Design and analysis using OO methodologies - Introduction to UML.

Practical (39 Hours)

The implementation has to be done using languages like C++/Java/C#.

1. Functions – Control structures – String handling – File handling
2. Error and Exception handling
3. Class – Object Instantiation
4. Principles of Inheritance, Encapsulation, Polymorphism – Overloading, Virtual functions.
5. OO Design with stress on interface specification.
6. Automated code generation and component reuse - UML

References:

1. B. Stroustrup, *The C++ Programming Language,* 3/e, Addison Wesley, 1997.
2. S. Oualline, *Practical C++ Programming,* 2/e, O'Reilly & Associates, 2002.
3. J. Nino and F. A. Hosch, *An introduction to programming and object oriented design using Java,* Wiley India, 2010

CS4088D ADVANCED HARDWARE LABORATORY

Prerequisites: NIL

L	T	P	C
1	0	3	3

Total Hours: 13T+39P

Theory (13 Hours)

Review of logic circuits with HDLs, Introduction to FPGAs, Programming with FPGAs, Embedded Computer Architecture Fundamentals, Processor Design Flow, General-Purpose Embedded Processor Cores, Customizable Processors and Processor Customization, Designing Soft-Core Processors for FPGAs

Introduction to GPUs, Programming with GPus, CUDA C, Tegra SoC as GPU mobile processor. Jetson TX2 GPU onboard supercomputer. Jetson based compute intensive project works for computer vision, robotics, Audio/Video processing and medicine

Practical (39 Hours)

Design and implement the following using FPGA

1. Finite State Machines.
2. Memory blocks.
3. A simple processor.
4. An enhanced processor.
5. Algorithms in hardware.

Design and implement the following using Jetson TX2 GPU board

6. Speech processing application
7. video processing
8. AI based projects (using deep learning)
9. Path planning for computer vision
10. Medicine projects

References:

1. J. Nurmi, *Processor Design: System-On-Chip Computing for ASICs and FPGAs,* 1/e, Springer, 2007
2. S. Palnitkar, *Verilog HDL,* 2/e, Pearson Education, 2003
3. B. J. LaMeres, *Introduction to Logic Circuits & Logic Design with Verilog*, 1/e, Springer, 2017.
4. NVIDIA, Whitepaper NVIDIA Tegra X1 NVIDIA'S New Mobile Superchip, https://international.download.nvidia.com/pdf/tegra/Tegra-X1-whitepaper-v1.0.pdf

CS2003D INTRODUCTION TO PROGRAMMING

Prerequisites: NIL

L	T	P	C
3	0	2	4

Total hours: 39T + 26P

Module 1: (13T+8P Hours)

Review of programming: Data types, Identifiers and keywords, variables, constants, arrays, expressions and statements, iterative and conditional constructs, break and continue, input and output statements, programming examples, bubble sort, insertion sort, sequential and binary search.

Module 2: (13T+10P Hours)

Introduction to complexity analysis: asymptotic notation and simple examples of analysis of iterative algorithms like bubble sort, insertion sort and binary search.
Subroutines: functions and parameter passing, call semantics, recursion, programming examples with recursive programs, recursive programs for binary search, quicksort, merge sort and heapsort. Complexity analysis of recursive programs using recurrences.

Module 3: (13T+8P Hours)

Structures and unions, pointers and dynamic memory allocation, programming examples: linked list, stack and queue implementation using linked lists, binary search trees, recursive inorder, preorder and postorder traversals, evaluation of arithmetic expressions.

References:

1. W. Kernighan, *The Practice of Programming*, Addison-Wesley, 1999.
2. A. V. Aho, J. E. Hopcroft, and J. D. Ullman, *Data Structures and Algorithms*, Addison-Wesley, 1983.
3. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms,* 3/e, MIT Press, 2009.

MA6010D DISCRETE MATHEMATICS

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 hours)

Propositional Calculus: Propositions, Truth tables , tautologies and contradictions, logical equivalence, logical arguments, normal forms, consistency completeness and independence, formal proofs , natural deduction. Predicate Calculus: predicates, quantifiers, arguments, theory of inference, resolution algorithm.

Module 2: (10 hours)

Relations and functions, pigeonhole principle, cardinals, countable and uncountable sets, diagonalization, equivalence relations and partitions, partial order, lattices, Boolean Algebra.

Module 3: (10 hours)

Semi groups, monoids, groups and subgroups, homomorphism, cosets, normal sub groups, products and quotients, Lagrange's theorem, permutation groups, Cayley's theorem.

Module 4: (9 hours)

Rings, Integral domains, fields, ideals and quotient rings, Euclidean domain, polynomial rings, division algorithm, field factorization, unique factorization, field extensions.

References

1. P. Grimaldi, *Discrete and Combinatorial Mathematics*, Addison Wesley, 1994.
2. J. P. Tremblay and R. Manohar, *Discrete Mathematical Structures with applications to Computer Science,* Tata McGraw Hill, New Delhi, 2003.
3. B. Kolman and R. C. Busby, *Discrete Mathematical Structures for Computer Science*, PHI, 1994.
4. C. L. Liu, *Elements of Discrete Mathematics,* 2/e, Mcgraw Hill, 1985.
5. J. L. Mott, A.Kandel, and T.P Baker, *Discrete Mathematics for Computer Scientists and Mathematicians*, 2/e, PHI, 1986.
6. J. K. Truss, Discrete Mathematics for Computer Scientists, Addison Wesley, 1999.
7. I. N. Herstein, *Topics in Algebra*, Wiley Eastern, 1975.

MA6020D STATISTICAL METHODS

Prerequisites: NIL

L	T	P	C
3	1	0	3

Total hours: 39

Module 1: (15 hours)

Probability distributions:- Introduction to Probability, Definitions and basic results, conditional probability and independence, Random variables, Mean and variance, Discrete probability distributions-Binomial distribution, Hyper- geometric distribution, Poisson distribution, Geometric distribution. Continuous probability distributions- Normal Distribution, Uniform distribution, Gamma distribution, Chi-Square distribution, Joint distribution of random variables.

Module 2: (12 hours)

Statistical inference I:- Population and samples, The sampling distribution of the mean ($\square^2$ known and $\square^2$ unknown), Sampling distribution of the variance, Point estimation and interval estimation, Tests of hypothesis, Hypothesis concerning one mean, Inference concerning two means. Estimation of variances, Hypothesis concerning one variance, Hypothesis concerning two variances.

Module 3: (12 hours)

Statistical Inference II – Inference concerning one proportion and two proportions, Analysis of r x c tables, Chi – square test for goodness of fit. Curve fitting by the method of least squares, Fitting straight lines, parabolas and other non-linear curves, Simple linear regression models, Inference concerning Correlation coefficient.

References:

1. R. A. Johnson and C. B. Gupta, *Miller & Freund's Probability and Statistics for Engineers*, 7/e, Pearson Education Inc, 2005.
2. W. H. Hines, Montgomery, et. al., *Probability and Statistics for Engineering*, John Wiley & Sons, Inc., 2003.
3. J. S. Milton and J. C. Arnold, *Introduction to Probability and Statistic*, 4/e, Tata McGraw-Hill, 2003.
4. Sheldon M. Ross, *A First Course in Probability*, 9/e, Pearson Education Inc, 2014.

MA6224D GRAPH THEORY AND COMBINATORICS

Prerequisites: NIL

L	T	P	C
3	1	0	3

Total hours: 39

Module 1: (9 hours)

Graphs: subgraphs, paths and cycles, isomorphism, cut vertex, bridge, block, bipartite graph, complement of a graph, line graph, Degree sequence, Trees, metric in graph, eccentricity , centre, median, centroid, Matrix representation of graph.

Module 2: (10 hours)

Connectivity: Vertex and Edge connectivity, Whitney's theorem, n - connected graphs Menger's' theorem.
Traversability: Hamiltonian graphs: Ore's theorem, Posa's theorem, Other sufficient conditions for hamiltonicity, Euler graphs, Planar graphs, Euler formula, platonic bodies. Non planar graphs.

Module 3: (10 hours)

Graph Coloring, chromatic polynomials, The four color problem, The five color theorem.
Digraphs: Connectedness - Acyclic Digraph, Strong digraphs, Tournaments, Directed trees, binary trees, weighted trees and prefix codes, BFS, DFS, Kruskal's, Prim's, Dijkstra's & Floyd's algorithms.

Module 4: (10 hours)

Generating functions, Partitions of integers, The exponential generating function, The summation operator, recurrence relations, first order and second order nonhomogeneous recurrence relations, method of generating functions.

References:

1. G. Chartrand and P. Zhang, *Introduction to Graph Theory*, McGraw Hill International Edition, 2005.
2. C. Vasudev, *Graph Theory with Applications*, New Age international publishers, 2006.
3. R. P. Grimaldi, *Discrete and Combinatorial Mathematics: An Applied Introduction,* Addison Wesley, 1994.
4. C. R. Foulds, *Graph Theory Applications*, Narosa Publishing House, 1994.
5. F. Harary, *Graph Theory*, Addison Wesley, 1972.
6. B. Bollobas, *Modern Graph Theory*, Springer Verlag, 2005.

MA6005D OPTIMIZATION TECHNIQUES I

Prerequisites: NIL

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 hours)

Elementary Linear Programming: Systems of linear equations & inequalities – Convex sets – Convex functions- Formulation of linear programming problems- Theory of Simplex method- Simplex Algorithm-Charnes M-Method- Two phase method-Duality in linear programming-Dual Simplex method

Module 2: (10 hours)

Advanced Linear Programming: Sensitivity analysis – Parametric programming- Bounded Variables problem- Transportation problem – Integrality property –MODI method- Degeneracy- Unbalanced problem – Assignment Problem – Development of Hungarian method – Routing problem.

Module 3: (10 hours)

Dynamic Programming and Game Theory: Nature of Dynamic Programming problem – Bellman's optimality principle. Cargo loading problem –Replacement problem- Multistage production planning and allocation problem-Rectangular Games- Two person –Zero sum games-Pure and mixed strategies-2xn and mx 2 games. Relation between theory of games and linear programming.

Module 4: (9 hours)

Network Path Models: Tree Networks – Minimal Spanning Tree - Kruskal's Algorithm, Prim's Algorithm – Shortest path problems- solution methods – Dijkstra's Method- Floyd's Algorithm –Network flow Algorithms-Maximal flow algorithm-The method of Ford and Fulkerson

References:

1. M. S. Bazarra, J. J. Jarvis, and H. D. Sherali, *Linear Programming and Network flows*, 2/e, John Wiley, 1990.
2. M.S. Bazaraa, H. D. Sherali, and C. M. Shetty, *Nonlinear Programming Theory and Algorithms*, 2/e, John Wiley,1993.
3. G. Hadley, *Linear Programming,* Narosa Publishing House,1990.
4. F. S. Hillier and G. T. Lieberman, *Introduction to OR*, 7/e, Mc.Grand Hill,2010
5. H. A. Taha, *Operations Research-An introduction,* 6/e, Prentice Hall,India, 1999.
6. L. R. Foulds, *Graph Theory and Applications*, Springer, Delhi,1992

CS3099D PROJECT

Prerequisites: NIL

L	T	P	C
-	-	-	15

Each student shall identify a faculty member as the project guide, with whom they associate for the project work for a period of one semester.

Student, in consultation with the guide, shall (i) Identify an area of work and conduct a detailed literature survey of the relevant work in the area, (ii) Identify a problem and prepare a report of the problem she is going to work on, (iii) Design a solution to the problem identified. This could be done either as an internal project (at NIT Calicut) or as an internship (at a Company, under guidance from one guide within the company/R&D organization/Collaborating institution in addition to the internal guide at NIT Calicut). The solution shall be implemented and the results, observations and conclusions tabulated. The design, results and conclusions shall be collected to form a project report which shall be presented before a committee of faculty members designated to evaluate the project work.

References:

1. G. J. Alred, C. T. Brusaw, and W. E. Oliu, *The Handbook of Technical Writing*, 11/e, Bedford/St. Martins, 2015.
2. G. R. Marczyk, D. DeMatteo, and D. Festinger, *Essentials of Research Design and Methodology,* Wiley, 2005.

MA2003D MATHEMATICS IV

Prerequisites: MA1001D Mathematics I, MA1002D Mathematics II

L	T	P	C
3	1	0	3

Total Hours: 39

Module 1: (9 hours)

Review of basic linear algebra topics, Direct sum of vector spaces, Rank-nullity theorem and its proof, Matrix representation of linear transformation, change of basis, Invariant subspaces, Polynomials applied to operators, Upper triangular representation for complex operators, Diagonalisation, Invariant subspaces on real vector spaces.

Module 2: (11 hours)

Inner product spaces, Orthogonal basis, Orthogonal projection, Best approximation, Linear functional, Adjoint of a linear transformation, Self-adjoint and normal operators, Spectral theorem for normal operators on complex inner product spaces, Spectral theorem for self adjoint operators, Normal operators on real inner product spaces, Positive operators, Isometries.

Module 3: (9 hours)

Complex functions, Derivative, Analytic function, Cauchy-Riemann equations, Laplace's equation. Geometry of analytic functions: Conformal mapping, Linear fractional Transformations, Schwarz - Christoffel transformation, Transformation by other functions.

Module 4: (10 hours)

Line integral in the Complex plane, Cauchy's Integral Theorem, Cauchy's Integral formula, Derivatives of analytic functions. Power series, Functions given by power series, Taylor series and Maclaurin series. Laurent's series, Singularities and Zeros, Residue integration method, Evaluation of real integrals.

References:

1. S. Axler, *Linear algebra done right*, 2/e, Springer, 2015.
2. S. Lipschutz and M. Lipson, *Schaum's outline of linear algebra*, 6/e, McGraw-Hill, 2017.
3. E. Kreyszig, H. Kreyszig, and E. J. Norminton, *Advanced engineering mathematics: international student version*, 10/e, New Delhi: Wiley, 2015.
4. C. R. Wylie and L. C. Barrett, *Advanced engineering mathematics*, 6/e, McGraw-Hill, 1995.