IIT Kharagpur - Course List

B.Tech in Computer Science and Engineering

Semester 1/2 (Chemistry)

BS10003	**Science of Living Systems**	2-0-0	2 Credits
CE13003	**Engineering Drawing and Computer Graphics**	1-0-3	3 Credits
CS10003	**Programming and Data Structures**	3-0-0	3 Credits
CS19003	**Programming and Data Structures Laboratory**	0-0-3	2 Credits
CY11003	**Chemistry**	3-1-0	4 Credits
CY19003	**Chemistry Laboratory**	0-0-3	2 Credits
DY17003	**DIY Project**	0-0-3	2 Credits
EA10007	**Extra Academic Activity-I**	0-0-3	1 Credits

Semester 2/1 (Physics)

EA10008	**Extra Academic Activity-II**	0-0-3	1 Credits
EE11003	**Electrical Technology**	3-1-0	4 Credits
EN19003	**Engineering Laboratory**	0-0-3	2 Credits
EV10003	**Environmental Science**	2-0-0	2 Credits
HS13003	**English for Communication**	2-0-2	3 Credits
MA11003	**Advanced Calculus**	3-1-0	4 Credits
MA11004	**Linear Algebra, Numerical and Complex Analysis**	3-1-0	4 Credits
ME11003	**Basic Engineering Mechanics**	3-1-0	4 Credits
PH11003	**Physics of Waves**	3-1-0	4 Credits
PH19003	**Physics Laboratory**	0-0-3	2 Credits

Semester 3

CS21201	**Discrete Structures**	3-1-0	4 Credits
CS21203	**Algorithms - I**	3-1-0	4 Credits
CS29203	**Algorithms Laboratory**	0-0-3	2 Credits
EA10009	**Extra Academic Activity-III**	0-0-3	1 Credits
EC21201	**Basic Electronics**	3-1-0	4 Credits
EC29201	**Basic Electronics Laboratory**	0-0-3	2 Credits
EE21201	**Signals and Systems**	3-1-0	4 Credits
MA20205	**Probability and Statistics**	3-0-0	3 Credits

Semester 4

CS21204	**Formal Language and Automata Theory**	3-1-0	4 Credits
CS20202	**Software Engineering**	3-0-0	3 Credits
CS29202	**Software Engineering Laboratory**	0-0-3	2 Credits
CS21202	**Switching Circuits and Logic Design**	3-1-0	4 Credits
CS29204	**Switching Circuits Laboratory**	0-0-3	2 Credits
CS29206	**Systems Programming Laboratory**	0-0-3	2 Credits
EA10010	**Extra Academic Activity-IV**	0-0-3	1 Credits

BE1	**Breadth Elective 1**		
HSSE1	**Humanities and Social Science Elective 1**		

Semester 5

CS31005	**Algorithms-II**	3-1-0	4 Credits
CS31007	**Computer Organisation and Architecture**	3-1-0	4 Credits
CS39001	**Computer Organisation Laboratory**	0-0-6	4 Credits
CS31003	**Compilers**	3-0-0	3 Credits
CS39003	**Compilers Laboratory**	0-0-3	2 Credits
BE2	**Breadth Elective 2**		
DE1	**Depth Elective 1**		

Semester 6

CS30202	**Database Management Systems**	3-0-0	3 Credits
CS39202	**Database Management Systems Laboratory**	0-0-3	2 Credits
CS31202	**Operating Systems**	3-1-0	4 Credits
CS39002	**Operating Systems Laboratory**	0-0-3	2 Credits
CS31204	**Computer Networks**	3-1-0	4 Credits
CS39006	**Networks Lab**	0-0-3	2 Credits
DE2	**Depth Elective 2**		

Semester 7

CS48003	**Summer Training**		
DBE1	**Depth/Breadth Elective 1**		
DBE2	**Depth/Breadth Elective 2**		
DE3	**Depth Elective 3**		
DE4	**Depth Elective 4**		
PROJ1	**Project 1**		

Semester 8

DBE3	**Depth/Breadth Elective 3**		
DBE4	**Depth/Breadth Elective 4**		
DE5	**Depth Elective 5**		
PROJ2	**Project 2**		

Detailed Curriculum

Semester 1/2 (Chemistry)

BS10003	**Science of Living Systems**	2-0-0	2 Credits

Unit 1: Cellular Biology (10 Lectures)

- Ultra structure of bacteria, plants and animal cells; cell division, cell cycle and apoptosis; ATP synthesis and Glycolysis; Respiration and photosynthesis.

Unit 2: Chemical Biology (10 Lectures)

- Proteins: structure and sequencing; Enzymes: mechanism, kinetics and inhibition; DNA: structure and sequence, replication, recombination; RNA synthesis; Genetic code and protein biosynthesis; Recombinant DNA technology.

Unit 3: Bio-Thermo-Fluidics and Transport Processes (8 Lectures)

- Noncovalent interactions and free energy changes in biological processes; Fundamentals of momentum, heat and mass transport as applied to biological systems; Human body as a thermodynamic system; Blood Rheology, Fluid mechanical aspects of some diseases and organs; Bio-Micro devices.

Unit 4: Impact of Biology on Society and Mankind (2 Lectures)

- Crop management, Disease control, Biological Hazards and safety; Unsolved Problems in Biology.

Suggested Books:

- Lehninger Principles of Biochemistry, Nelson and Cox,
- Biochemistry by Berg, Tymoczko and Stryer
- Biochemistry by Voet and Voet
- Molecular Cell Biology by Lodish et al
- Molecular Biology of Genes by Watson et al.
- Gene IX by Benjamin Lewin
- Biothermal-Fluid Sciences Principles and Applications, by W-J Yang

CE13003	**Engineering Drawing and Computer Graphics**	1-0-3	3 Credits

1) Introduction to Manual Drawing (MD); geometrical constructions:
   a) dividing a line into several equal segments,
   b) bisect and trisect an angle,
   c) drawing regular polygons,
   d) length of arcs, circles and lines in contact,
   e) inscribed circles.
2) Introduction to Computer Aided Drafting (CAD) using FreeCAD/Google Sketch; Engineering curves: (1) Ellipse, (2) parabola, (3) hyperbola
3) Engineering curves: (4) cycloid, (5) trochoid, (6) involute, (7) evolute and (8) spirals. CAD assignment and discussion.
4) Orthographic Projection: (a) Points, (b) Lines, (c) Traces of lines. CAD assignment discussion.
5) Projections of Planes: (a) projections on perpendicular planes, (b) projections on auxiliary planes, (c) traces of planes. CAD assignment and discussion.
6) Projections of regular solids: cubes, prisms, cylinders, cones, pyramids, tetrahedron. CAD assignment and discussion.
7) Isometric Projections and views of solids. CAD assignment and discussion.
8) Sections of solids having regular geometric shapes: cubes, prisms, cylinders, cones, pyramids, tetrahedron, spheres. CAD assignment and discussion.
9) Development of Surfaces: cylinders, cones, prisms; introduction to non-developable surfaces. CAD assignment and discussion.
10) MD Examination
11) CAD Examination

CS10003	**Programming and Data Structures**	3-0-0	3 Credits

Introduction - Basic operation of digital computers, basic concepts of integer and floating point number representations. Elements of C programmin language - data types, constants, and variables, expressions and assignment statements, input and output statements, conditional and branch statements, iteration statements, 1-D and 2-D arrays, functions and parameter passing; recursion, strings, structures, introduction to pointers and dynamic allocation,file read and write. Searching and sorting - Linear and binary search, selection sort, bubble sort, insertion sort, merge sort, quick sort. Data structures: Linked lists, stacks, queues.

CS19003	**Programming and Data Structures Laboratory**	0-0-3	2 Credits

Topics of Lab Assignments

1) Familiarization with C Programming Environment
2) Data types, constants, and variables, assignment statements and input-output
3) Conditional and branch statements
4) Loops and iteration statements
5) 1-d and 2-d static arrays
6) Functions and recursion
7) Structures
8) Pointers and dynamic memory allocation
9) Linked lists
10) Stacks and queues

CY11003	**Chemistry**	3-1-0	4 Credits

Module 1 Physical Chemistry

- Principles of Thermodynamics: First and Second Law of Thermodynamics, Concept of Entropy, Helmholtz and Gibbs free energy, Equilibrium and spontaneity conditions for Closed Systems, Maxwell Relations, The Chemical Potential; Definition and Concept of Open Systems.
- Applications: Phase equilibria, Reaction Equilibria, Electrochemical Equilibrium, Application of thermodynamics to real world Problems.

Module 2 Inorganic Chemistry

- Bonding and Coordination Chemistry: Bonding in homo (Li2 to N2, O2 and F2) and hetero (CO only) dinuclear systems. CFT and its applications.
- Metal ions from laboratory to living systems: Spectroscopic, magnetic, functional properties of new age coordination compounds and Hemoglobin.
- Organometallics and Catalysis: Metal carbonyls. Oxidative addition and reductive elimination, insertion and elimination reactions. Hydrogenation (Wilkinson's catalyst) and Carbonylation (Monsanto process).
- Redox Chemistry: Diagrammatic representation and use of Latimer and Frost diagrams. Applications of redox chemistry in energy storage (primary and secondary batteries).
- Materials Chemistry: Metal oxides, spinels, superconductors, and boron nitride.

Module 3 Organic Chemistry

- Understanding the 3-D Structure of Organic Compounds: Concept of chirality and molecular structure (basic symmetry elements Sigma -plane and inversion centre); Representations in 2D and 3D forms; Absolute configuration and CIP nomenclature (case studies); Molecules devoid of point chirality (allenes and biphenyls, brief discussion); Significance of chirality in living systems (brief discussion) Conformational analysis (definition and implication); Dihedral angle, torsional angle and strain); Few acyclic systems (Gauche butane interactions); Few monocyclic systems and its conformational aspects (Cyclopropane to Cyclohexanes)
- Initial Strategies towards the Synthesis of New Chemical Entities: Nucleophilic Substitution reaction at saturated carbon (SN2/SN1 and SNi reaction; definitely brief SNi and NGP in detail), Stereochemical implication of SN reactions.

- Elimination reaction: Syn 1,2 elimination reactions (Cope and related reactions with examples)

CY19003	**Chemistry Laboratory**	0-0-3	2 Credits

Physical Chemistry (Any 4 from the list given below)

1) Determination of heat of neutralization of acid by base
2) Conductometric titration
3) Chemical Kinetics
4) Effect of surfactants on the surface tension of water
5) Solubility of a sparingly soluble salt in water 6. pH metric titration

Inorganic Chemistry (Any 4 from the list given below)

1) Spectrophotometric determination of acid dissociation constant of methyl red an acid base indicator
2) Potentiometric titration of a given sodium carbonate solution with aqueous hydrochloric acid solution 3. Determination of sodium (Na+) and potassium ion (K+) concentrations in any mineral or drinking water sample
4) Estimation of sulphate ion in Tap Water by Nepheloturbidimetric analysis
5) Estimation of iodine content in iodized salt by iodometric redox titration
6) Experimental verification of crystal field theory (CFT) and the spectrochemical series using cobalt(III) complexes

Organic Chemistry (ALL 4 from the list given below)

1) Analysis of unknown organic solid sample
2) Analysis of unknown organic liquid sample
3) Synthesis of benzoic acid using household bleach
4) Reaction rate comparison for nucleophilic substitution reaction of organic halides

DY17003	**DIY Project**	0-0-3	2 Credits

EA10007	**Extra Academic Activity-I**	0-0-3	1 Credits

1) Natural Cultural Appreciation (NCA)
2) National Cadet Corps (NCC)
3) National Service Scheme (NSS)
4) Health and Fitness
5) NSO (Sports and Games)

Semester 2/1 (Physics)

EA10008	**Extra Academic Activity-II**	0-0-3	1 Credits

1) Natural Cultural Appreciation (NCA)
2) National Cadet Corps (NCC)
3) National Service Scheme (NSS)
4) Health and Fitness
5) NSO (Sports and Games)

EE11003	**Electrical Technology**	3-1-0	4 Credits

Module A

- Theory component: Introduction (3 Lectures) 1-3 (NPTEL MODULE 1/Chapters 1-2 in DelToro)
  Sources of Electrical energy; General structure of electrical power systems; Voltage SourceBattery and Current Source – Solar Cell.
- DC Networks: (3 Lectures) 4-6 (NPTEL MODULE 2/Chapter 3 in DelToro)
  Node voltage and mesh current methods, Concept of Ground and Earthing, Superposition principle, Thevenin's and Norton's theorems.

- Transients: (4 Lectures) 7-10 (NPTEL MODULE 3/Chapter 5 in DelToro)
  Introduction to Inductance and Capacitance. Differential equation formulation for the solution of DC networks comprising R-L and R-C circuits. Concept of time constant and derivation of the time domain solution. Response to Sinusoidal Excitation.

Module B
- Single phase AC circuits: (6.5 Lectures) 11-16.5 (NPTEL MODULE 4/Chapters 7 up to 7.10 in DelToro)
  Single phase EMF generation,average and effective values of sinusoids, solution of R,L,C series circuits, the j operator, complex representation of impedances, phasor diagram, power factor, power in complex notation, solution of parallel and series – parallel circuits, Resonance series, parallel. Maximum power transfer theorem. Network Solutions in ac.

Module C
- Three phase AC Circuits: (5.5Lectures) 16.5-22 (NPTEL MODULE 5/Section 7.11 in DelToro)
  Three phase EMF generation, delta and Y – connection, line and phase quantities, solution of three phase circuits, balanced supply voltage and balanced load, phasor diagram, measurement of power in three phase circuits, Three phase four wire circuits.

Module D
- Magnetic Circuits: (2 Lectures) 23-24 (NPTEL MODULE 6/Chapter 15 in DelToro)
  Ampere's circuital law, B- H curve, solution of magnetic circuits, hysteresis and eddy current losses
- Transformers: (5 Lectures) 25-30 (NPTEL MODULE 7/Chapter 16 in DelToro)
  Construction, EMF equation, ratings, phasor diagram on no load and full load, equivalent circuit,regulation and efficiency calculations, open and short circuit tests, auto-transformers.

Module E
- Induction Motor: (6 Lectures) 31-36 (NPTEL MODULE 8/Chapters 17-18 in DelToro)
  The revolving magnetic field, principle of orientation, ratings, equivalent circuit, Torque – speed characteristics, starters for cage and wound rotor type induction motor. Electrical Safety.

Books
- Text Book: https://nptel.ac.in/courses/108/105/108105053/
- Electrical Engineering Fundamentals by Vincent Del Toro Prentice Hall of India available on Amazon Second Edition printed in 2015 by Pearson

EN19003	**Engineering Laboratory**	0-0-3	2 Credits

List of Experiments
1) Turning a cylindrical job according to a drawing that involves the following operations- straight turning, taper turning, grooving, threading
2) Milling a cylindrical job to hexagonal shape using indexing head
3) Making a CNC programme for a cylindrical job and executing the same in a CNC lathe
4) Lap and butt joining of low carbon steel using manual metal arc welding method
5) Making a mould from a given pattern, and pouring molten aluminium in the mould
6) Characteristics of Fluorescent and Incandescent Lamp
7) Verification of Network Theorems
8) R-L-C Series Circuit
9) Three phase power measurement by two Wattmeter method
10) Open-Circuit and Short-Circuit Test of Single Phase Transformer
11) Load test of Three Phase Induction Motor

EV10003	**Environmental Science**	2-0-0	2 Credits

- **Environmental Problems, Their Causes, and Sustainability**: Causes of modern environmental concerns (overpopulation, tragedy of the commons, affluenza, poverty); IPAT model for human impact on the environment; Ecological footprint analysis; Earth Overshoot Day; Sustainable development – its need and importance; Principles of sustainability; Environmentally sustainable societies; 2030 Agenda for sustainable development

- **Ecosystems**: What are they and how do they work; Matter and energy flow in ecosystems; Natural capital and ecosystem services (provisioning services, regulating services, cultural services); Role of biogeochemical cycles in globalization and sustainable development
- **Human Population and Urbanization**: Population explosion, urbanization and sustainability; Challenges of megacities; Spatial patterns of urbanization; Urban sprawl – causes, consequences and regulation; Smart growth, eco-cities and sustainable mobility
- **Understanding Air Pollution**: Air pollutants – classification, sources and impacts, Clean air act and national ambient air quality standards (NAAQS); Air quality index; Ground level ozone and photochemical smog; Long-range transboundary air pollution; Ozone depletion in the Antartic stratosphere and the Montreal Protocol; Understanding and improving indoor air quality
- **Climate Change**: Evidence, causes and effects, Keeling curve; Global warming potential; Role of IPCC in the understanding of climate change; Global climate agreements – The United Nations Framework Convention on Climate Change, the Kyoto Protocol, and the Paris Agreement; Mitigation strategies – carbon capture, utilization and storage; adapting to climate change Energy and Sustainability: Global energy trilemma; Energy efficiency and conservation; Renewable energy for human sustainability (solar, wind, hydroelectricity, biomass, and geothermal energy)
- **Waste Management**: Consumerism and our throw-away culture; Characteristics of municipal solid waste; Sustainable practices in waste management; CPHEEO guidelines for solid waste management; Transition to zero waste lifestyle; Tackling the rise of ewaste; Looming waste crisis from global renewable energy boom
- **Industrial Ecology and Circular Economy**: Urban ecology and urban metabolism; material and energy flows of leading global economies; origin of industrial ecology, its definition and its relation to the concept of sustainability; closing material loops (open vs. closed-loop systems) and transition to a circular economy; circular business models; industrial symbiosis – Kalundborg Eco-Industrial Park
- **Tackling Water Pollution**: Sources of water pollution; Classification of water pollutants; Overview of water pollution mitigation measures; Applicable wastewater discharge standards (new standard by the National Green Tribunal) and typical flow schemes for sewage treatment plant; Potable water quality requirements (IS 10500); Water quality index; Overview of water treatment plant
- **Noise Pollution**: Sources and effects of noise; quantification of noise pollution (Leq, LAeq, etc.); Control and regulation rules in India

HS13003	**English for Communication**	2-0-2	3 Credits

Theory Classes (Class Lectures)

Module 1 - Communication: Practical Lessons and Socio-Cultural Dimensions

This module will sensitize the students to the aesthetics, ethics and social dimensions of communication in general and those of communication in English in particular. It will also focus on the practical aspects of communication in the professional contexts.

1) Communication skills: definition and practical dimensions
2) Communication in the contemporary world: Communication and technology
3) Communication in workplaces
4) Ethical dimensions of communication
5) Effective communication in English: Cross-cultural contexts
6) Speaking and writing in English with confidence: Practical lessons

Module 2 - Literary Communication: Creative Application of Language

This module will familiarize the students with certain literary texts and teach them how communication is not simply a mechanical process of sending/receiving (or encoding/decoding) a message but also a creative process that enlarges the scope of meaning-making in our lives. A significant instance of this process of meaning-making would be the creative use of language by a litterateur and the creative reception of a literary text by the intelligent and imaginative reader. When the students read literary texts and give critical responses to them they are enabled to formulate and express their thoughts in a concrete way, which is one of the basic requirements for genuinely effective communication. Literary texts also familiarize them with the ways people communicate with each other in the real world - this enhances the communication skills of the learners in an indirect but very fruitful way.

1) Examples of culture-specific use of language and their implications: “Indian English” poems
2) Is there any absolute standard for speaking good English? – Views of great writers
3) Rhetorical force and persuasive power of poetic utterances: Relevant texts
4) Spiritual communication: Instances of spiritual literature
5) The power of language: Critical perspectives from world literature

[The texts/web-links to the texts will be provided to the students]

I. Language Lab Activities The following topics would be taught in the language lab classes in an interactive way, involving the students in a creative process of learning the English language. Here, they will find a pedagogic ecosystem that involves a dialogic method of teaching language effectively.

1) Grammar: Parts of speech, interchange of parts of speech, clauses, subject-verb agreement, tense, number, gender, punctuation marks
2) Speaking and presentation: Speaking effectively and confidently in English on a given topic; group presentation; debate; public speech; PPT presentation etc.
3) Effective Listening: Listening to speeches in English (especially those in foreign accents) and understanding their meaning
4) Reading and comprehension: Reading passages in English aloud and comprehending and critically responding to them
5) Writing and composition: Writing CVs, job applications, leave applications, reports, short paragraphs on socially relevant topics etc.

MA11003	**Advanced Calculus**	3-1-0	4 Credits

1) **Differential Calculus**: Lagrange’s mean value theorem, Cauchy’s mean value theorem, Taylor’s and Maclaurin’s theorem. Functions of several variables: Limit, continuity, partial derivatives and their geometrical interpretation, total differential and differentiability, derivatives of composite and implicit functions, derivatives of higher order and their commutativity, Euler’s theorem on homogeneous functions, Taylor’s expansion of functions, maxima and minima, constrained maxima/ minima problems using Lagrange’s method of multipliers.
2) **Differential Equations**: First order exact differential equations, general linear differential equations with constants coefficients, method of variation of parameters, Cauchy-Euler equations. Power series solutions of ODE’s.
3) **Integral Calculus**: Improper integrals and tests for convergence, Beta and Gamma functions and their elementary properties. Differentiation under integral sign including variables limits-Leibnitz rule. Double and triple integrals, changing the order of integration, change of variables - Jacobian of a transformation, computation of surface area and volume.
4) **Vector Calculus**: Definition of vector and scalar fields, level surfaces, limit, continuity, differentiability of vector functions. Directional derivative, gradient, curl, divergence and their geometrical interpretation. Line integral, path independence of line integrals, Green’s theorem, surface integral, Gauss divergence theorem , Stokes theorem.

MA11004	**Linear Algebra, Numerical and Complex Analysis**	3-1-0	4 Credits

Prerequisite: None

Category: Old (Modified)

1) **Linear Algebra:**

   Vector spaces over real/complex field, subspaces, linear combination, spanning set. [2 Lectures]

   Linear dependence and independence of vectors, echelon form of matrices, basis and dimension of vector spaces [3 Lectures]

   Rank of a matrix, Linear transformation, rank-nullity theorem, matrix representation of a linear transformation. [3 Lectures]

   Solution of system of linear homogeneous and nonhomogeneous equations using rank concept and Gauss elimination method. [3 Lectures]

   Eigenvalues and Eigenvectors of matrices and their properties (Hermitian, Skew-Hermitian, Unitary matrices), diagonalization, Cayley-Hamilton Theorem (statement only). [3 Lectures]

Inner product, Norms of vectors, orthogonal vectors, Cauchy Schwarz Inequality (statement only). [3 Lectures]

2) **Numerical Analysis:**
   Iterative method for solution of system of linear equations Jacobi and Gauss Seidel method. [3 Lectures]
   Solution for transcendental equations: Bisection, Regular Falsi methods, Fixed point iteration, Newton-Raphson methods. [3 Lectures]
   Finite differences, Interpolation, error in interpolation Polynomial, Newtons forward and backward interpolation formula, Lagranges interpolation formula. [3 Lectures]
   Trapezoidal and Simpsons 13 rules for numerical integration. [2 Lectures]
3) **Complex Analysis:**
   Limit, continuity, differentiabilty and analyticity of functions, Cauchy-Riemann equations, harmonic conjugates. [3 Lectures]
   Line integrals in complex plane, Path independence. [2 Lectures]
   Cauchy s integral formula, derivatives of analytic functions, Cauchy's integral theorem [2 Lectures]
   Singularities, Taylor s series, Laurent series [3 Lectures]
   Residue theorem, evaluation of real integrals [2 Lectures]

References:

1) Advanced Engineering Mathematics, by Erwin Kreyszig, 10th edition, John wiley and Sons, 2017.
2) Introduction to Linear Algebra, by Gilbert Strang, 5th edition, Wellesley-Cambridge Press, 2016

ME11003	**Basic Engineering Mechanics**	3-1-0	4 Credits

1) Vector Mechanics with applications: Definition and representation of vectors, projection and decomposition, force vector and types, dot product, resolving force vector along and perpendicular to a given direction, cross product and scalar triple product, moment of force about a point and axis, force couple and couple moment, force system, simple distributed force, parallel and concurrent force systems, equivalent force system and simplest resultant, applications.
2) Equilibrium in 2D and 3D - Constraints, Free-body diagrams, Equations of static equilibrium, special cases like two-force, three-force and multi-force applications, plane trusses and frames.
3) Friction - Coulomb friction, tipping vs sliding, flat belt drives and pulleys, screw-jack, rolling resistance.
4) Internal Forces - axial force and torque diagrams, Shear force and bending moment diagrams.
5) Concept of Stress and Strain - Stressstrain diagram, factor of safety, uniaxial loading, single and double shear, applications.
6) Generalized Hooke's law - Poisson's ratio, Generalized Hooke's law, Relations between E, nu, G and K
7) Indeterminate problems involving uniaxial loading.

Text Books:

1) Vector Mechanics for Engineers - Statics and Dynamics (12th Edition, SIE) by Ferdinand P. Beer, E. Russell Johnston Jr., et al. | 2019.
2) Mechanics of Materials, 8th Edition, SI Units by Ferdinand Beer, E. Johnston, et al. | 2020.

PH11003	**Physics of Waves**	3-1-0	4 Credits

- Review of Simple Harmonic Motion, Damped and Forced oscillations, Resonance, Coupled oscillations, Normal modes. Wave Motion, longitudinal and transverse waves, wave equation, plane waves, phase velocity, superposition, wave packets and group velocity, dispersion relations, two- and three-dimensional waves.
- Electromagnetic Waves, Energy-momentum, Poynting's theorem,reflection and refraction, Stokes relations.
- Superposition of waves, Interference, Coherence, Two-beam and Multi-beam interference,Fresnel Biprism and Mirrors, Newton's rings, Michelson and Fabry-Perot Interferometers, Thin films, Diffraction, Fraunhofer single slit diffraction and Grating, Polarisation, Birefringence, Retarders.

- Failure of classical physics, Planck's spectrum, Compton Effect, Davisson-Germer Experiment and Thomson Experiment, de Broglie waves, Uncertainty principle. Observables and Hermitian Operators, Wave function and Schrodinger equation, Probability interpretation, One-dimensional problems.

PH19003	**Physics Laboratory**	0-0-3	2 Credits

1) Pohl's Pendulum: To study forced oscillations and to plot resonance curves for different damping.
2) Coupled Pendula: To study normal modes and to determine the normal frequencies of a coupled pendula.
3) Newton's Rings: To study the interference fringes of equal thickness to determine the wavelength of Sodium light.
4) Michelson Interferometer: To study the interference fringes of equal inclination and to determine the wavelength of He-Ne laser light.
5) Single Slit Diffraction: To study the single slit Fraunhofer diffraction and to plot the intensity distribution of diffraction pattern by a slit.
6) Diffraction Grating: To study the multi-slit Fraunhofer diffraction and to determine the wavelengths of Mercury spectral lines.
7) Prism Spectrometer: To study the prism dispersion and to plot refractive index vs wavelength curve.
8) Polarimeter: To study polarised light and to determine the specific rotation of an optically active substance by a polarimeter.
9) Stretched Strings and Air Columns: To study transverse and longitudinal waves and to determine the phase velocity of waves produced in an ordinary string and to determine the speed of sound in air.
10) Photoelectric Effect: To study the Photoelectric effect and to determine Planck's quantum of action.

Semester 3

CS21201	**Discrete Structures**	3-1-0	4 Credits

- Propositional logic: Syntax, semantics, valid, satisfiable and unsatisfiable formulas, encoding and examining the validity of some logical arguments.
- Proof techniques: forward proof, proof by contradiction, contrapositive proofs, proof of necessity and sufficiency.
- Sets, relations and functions: Operations on sets, relations and functions, binary relations, partial ordering relations, equivalence relations, principles of mathematical induction.
- Size of a set: Finite and infinite sets, countable and uncountable sets, Cantos diagonal argument and the power set theorem, Schroeder-Bernstein theorem.
- Introduction to counting: Basic counting techniques - inclusion and exclusion, pigeon-hole principle, permutation, combination, summations. Introduction to recurrence relation and generating function.
- Algebraic structures and morphisms: Algebraic structures with one binary operation - semigroups, monoids and groups, congruence relation and quotient structures. Free and cyclic monoids and groups, permutation groups, substructures, normal subgroups. Algebraic structures with two binary operations - rings, integral domains and fields. Boolean algebra and Boolean ring.
- Introduction to graphs: Graphs and their basic properties - degree, path, cycle, subgraphs, isomorphism, Eulerian and Hamiltonian walks, graph coloring, planar graphs, trees.

References

1) Kenneth H. Rosen, Discrete Mathematics and its Applications, Tata McGraw-Hill.
2) C. L. Liu, Elements of Discrete Mathematics, Tata McGraw-Hill.
3) Norman L. Biggs, Discrete Mathematics, Oxford University Press.
4) Kenneth Bogart, Clifford Stein and Robert L. Drysdale, Discrete Mathematics for Computer Science, Key College Publishing.
5) Thomas Koshy, Discrete Mathematics with Applications, Elsevier.
6) Ralph P. Grimaldi, Discrete and Combinatorial Mathematics, Pearson Education, Asia.

CS21203	**Algorithms - I**	3-1-0	4 Credits

- Asymptotic notations and their significance, introduction to RAM model of computation, complexity analysis of algorithms, worst case and average case.
- Basic introduction to algorithmic paradigms like divide and conquer, recursion, greedy, etc. Searching: binary search trees, balanced binary search trees, AVL trees and Red-black trees, B-trees, skip lists, hashing.
- Priority queues, heaps, Interval trees, tries.Order statistics.
- Sorting: comparison based sorting - quick sort, heap sort, merge sort: worst and average case analysis.
- Decision tree model and (worst case) lower bound on sorting. Sorting in linear time - radix sort, bucket sort, counting sort, etc.
- String matching
- Graph Algorithms: BFS, DFS, connected components, topological sort, minimum spanning trees, shortest paths - single source and all pairs.

CS29203	**Algorithms Laboratory**	0-0-3	2 Credits

The laboratory component will emphasize two areas:

- Implementation of algorithms covered in class: This will involve running the algorithms under varying input sets and measuring running times, use of different data structures for the same algorithm (wherever applicable) to see its effect on time and space, comparison of different algorithms for the same problem etc.
- Design of Algorithms: This will involve design and implementation of algorithms for problems not covered in class but related to a topic covered in class. The exact set of algorithms to design and implement is to be decided by the instructor. In addition, there will be at least one significantly large design project involving some real world application. An efficient design of the project should require the use of multiple data structures and a combination of different algorithms/techniques.

References

1) T. H. Cormen, C. L. Leiserson, R. L. Rivest, and C. Stein, Introduction to Algorithms, MIT Press.
2) J. Kleinberg and E. Tardos, Algorithm Design, Addison-Wesley.
3) Harry R. Lewis and Larry Denenberg, Data Structures and Their Algorithms, Harper Collins.
4) A. Gibbons, Algorithmic Graph Theory, Cambridge University Press.
5) Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, John Wiley.
6) R. Sedgewick, Algorithms in C (Parts 1-5), Addison Wesley.
7) M. H. Alsuwaiyel, Algorithm Design Techniques and Analysis, World Scientific.
8) Gilles Brassard and Paul Bratley, Algorithmics : theory and practice, Prentice-Hall.
9) Udi Manber, Introduction to Algorithms: A Creative Approach, Addison-Wesley.
10) Sara Baase and Allen Van Gelder, Computer Algorithms: Introduction to Design and Analysis, Addison-Wesley.

EA10009	**Extra Academic Activity-III**	0-0-3	1 Credits

1) Natural Cultural Appreciation (NCA)
2) National Cadet Corps (NCC)
3) National Service Scheme (NSS)
4) Health and Fitness
5) NSO (Sports and Games)

EC21201	**Basic Electronics**	3-1-0	4 Credits

- **Introduction**: Electronic system as a conglomeration of several subsystems, such as transducer, amplifier, filter, oscillator, data converter, display device, power supply etc., examples of typical electronic systems (mobile phone, portable CD player etc.), basic concept of signal, noise, etc.
- **Semiconductor devices**: Diode, BJT, MOSFET, their structures and principle of operations.

- **Amplifiers**: Functionality, specifications (voltage gain, current gain, input resistance, output resistance, dynamic range, bandwidth, linearity, power efficiency etc.), effect of cascading, various applications and typical circuits.
- **Filters**: Low pass, high pass, band pass and band stop filters, single and higher order passive filter topologies (RC and LC), specifications (cutoff frequency, roll off, etc.).
- **Feedback**: Basic concept of negative and positive feedback, application of negative feedback in amplifiers, effect on gain, bandwidth, input resistance, output resistance and desensitivity to parameter variations.
- **Oscillators**: Barkhausen criterion, sinusoidal and non-sinusoidal oscillators, applications and typical circuits.
- **Operational amplifier**: Differential mode of operation, common mode rejection, typical op-amp specifications (open loop gain, differential input resistance, unity gainbandwidth etc.), inverting amplifier, non-inverting amplifier, integrator, differentiator, summing amplifier etc., concept of active filters.
- **Power electronics**: Half wave and full wave rectification, filtering, regulation with zener diode and linear regulators, switched mode power supply.
- **Digital electronics**: Review of Boolean algebra and signed number representation schemes in binary, implementation of Boolean functions using various logic gates, concept of combinatorial and sequential circuits, registers and counters from functional viewpoint, concept of programmable processors and microcontrollers. Introduction to analog-to-digital and digital-to-analog data converters, their speed and resolution, basic concept of aliasing in the sampling process.

EC29201	**Basic Electronics Laboratory**	0-0-3	2 Credits

1) Familiarization with electronic components and usage of multimeter
2) Familiarization with oscilloscope, signal generator and further usage of multimeters
3) Frequency-response and square-wave testing of R-C, C-R and R-L networks
4) Voltage Rectifiers
5) Studies on Common-Emitter amplifiers
6) Studies on analog circuits using OP-AMP
7) Studies on logic gates

EE21201	**Signals and Systems**	3-1-0	4 Credits

The subject covers both the continuous-time and discrete-time signals and systems. Both time and frequency-domain analysis will be covered.

- Continuous-time (CT) and Discrete-time (DT) signals, Operation on signals, Sinusoid and Exponential Signals, Periodicity, Power and Energy, Unit Impulse, Step, and Ramp Functions, Measure of signals. Basic System Properties: Systems with and without Memory, Invertibility and Inverse Systems, Causality, Time Invariance and Linearity. (3 Lectures)
- DT and CT Linear Time-invariant (LTI) Systems, Representation of CT and DT Signals in terms of Impulse, Impulse Response of LTI systems and Convolution Integral, Properties of LTI Systems, Causal LTI Systems Described by Differential and Difference Equations and its Block Diagram and signal flow Representations (7 Lectures)
- Response of LTI Systems to Complex Exponentials, Fourier Series Representation of CT and DT Periodic Signals, Convergence and Properties of the Fourier Series, Fourier Series, Parseval's Relation, Induced gain of LTI systems, LTI systems with Periodic Inputs (6 Lectures)
- Representation of Aperiodic Signals: The CT and DT Fourier Transform, its Convergence and Examples, The Fourier Transform for Periodic Signals, Properties: Convolution, Multiplication and Duality (7 Lectures)
- A brief Overview of the Laplace Transform (1 Lecture)
- Transfer function, Concept of Poles and Zeros, Causality, Stability of LTI Systems, Block Diagram Representations of Causal LTI systems with Some Examples of Physical Systems (3 Lectures)

- The z-Transform, the Region of Convergence, Properties of the zTransforms, Inverse z-transform, Initial- and Final-value Theorems in vz-domain Transfer Function in z-Domain, Stability of LTI Systems in z-Domain, Block Diagram Representations of LTI Systems in z-Domain (5 Lectures)
- Time Response of First-Order and Second-Order LTI Systems and Time-Domain Characterization - Rise time, Settling Time, Peak Overshoot, and Steady-state Error Specifications, Effect of Addition of Poles and Zeros - Concept of Dominant Poles and Zeros. Frequency Response of LTI Systems and Frequency-Domain Characterization, Asymptotic Bode (Magnitude and Phase) Plot (9 Lectures)
- Concept of Feedback Systems, Open-Loop and Closed-Loop Systems, Advantages of Feedback, Stability of a Feedback System (2 Lectures)

Reference Books:

1) Signals and Systems, Alan V.Oppenheim, Alan S.Willsky and S. Hamid Nawab, Pearson Education India; 2nd edition, 2015.

MA20205	**Probability and Statistics**	3-0-0	3 Credits

Prerequisites: NA

Category: OLD (Modified) MA20104

1) Probability: Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence, problems. (6 Lectures)
2) Random Variables and their distributions: Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, moment generating function, median and quantiles, Chebyshev's inequality, problems. (4 Lectures)
3) Special Distributions: Discrete uniform, binomial, geometric, negative binomial, hypergeometric, Poisson, continuous uniform, exponential, gamma, Weibull, Pareto, beta, normal, Cauchy distributions, reliability of series and parallel systems, problems. (6 Lectures)
4) Function of a Random Variable: Distribution of function of a random variable, problems. (2 Lecture)
5) Joint Distributions: Joint, marginal and conditional distributions, product moments, correlation, independence of random variables, bivariate normal distribution, problems. (4 Lectures)
6) Transformations: functions of random vectors, distributions of sums of random variables, problems. (2 Lectures)
7) Sampling Distributions: The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions, problems. (2 Lectures)
8) Estimation: Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions, problems. (4 Lectures)
9) Testing of Hypotheses: Null and alternative hypotheses, the critical and acceptance regions, two types of error, power of the test, the most powerful test and Neyman-Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for proportions, Chi-square goodness of fit test and its applications, problems. (6 Lectures)

References:

1) An Introduction to Probability and Statistics by V.K. Rohatgi and A.K. Md. E. Saleh
2) Probability and Statistical Inference by Hogg, R.V., Tanis, E.A. and Zimmerman D. L.
3) Probability and Statistics in Engineering by W.W. Hines, D.C. Montgomery, D.M. Goldsman, C.M. Borror
4) Introduction to Probability and Statistics for Engineers and Scientists by S.M. Ross
5) Introduction to Probability and Statistics by J.S. Milton and J.C. Arnold.
6) Introduction to Probability Theory and Statistical Inference by H.J. Larson
7) Probability and Statistics for Engineers and Scientists by R.E. Walpole, R.H. Myers, S.L. Myers, Keying Ye
8) Modern Mathematical Statistics by E.J. Dudewicz and S.N. Mishra
9) Introduction to the Theory of Statistics by A.M. Mood, F.A. Graybill and D.C. Boes

Semester 4

CS21204	**Formal Language and Automata Theory**	3-1-0	4 Credits

- **Introduction**: Alphabet, languages and grammars, productions and derivation, Chomsky hierarchy of languages.
- **Regular languages and finite automata**: Regular expressions and languages, deterministic finite automata (DFA) and equivalence with regular expressions, nondeterministic finite automata (NFA) and equivalence with DFA, regular grammars and equivalence with finite automata, properties of regular languages, pumping lemma for regular languages, minimization of finite automata.
- **Context-free languages and pushdown automata**: Context-free grammars (CFG) and languages (CFL), Chomsky and Greibach normal forms, nondeterministic pushdown automata (PDA) and equivalence with CFG, parse trees, ambiguity in CFG, pumping lemma for context-free languages, deterministic pushdown automata, closure properties of CFLs.
- **Context-sensitive languages**: Context-sensitive grammars (CSG) and languages, linear bounded automata and equivalence with CSG.
- **Turing machines**: The basic model for Turing machines (TM), Turing-recognizable (recursively enumerable) and Turing-decidable (recursive) languages and their closure properties, variants of Turing machines, nondeterministic TMs and equivalence with deterministic TMs, unrestricted grammars and equivalence with Turing machines, TMs as enumerators.
- **Undecidability**: Church-Turing thesis, universal Turing machine, the universal and diagonalization languages, reduction between languages and Rice s theorem, undecidable problems about languages.

References

1) Harry R. Lewis and Christos H. Papadimitriou, Elements of the Theory of Computation, Pearson Education Asia.
2) John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation, Pearson Education Asia.
3) Dexter C. Kozen, Automata and Computability, Undergraduate Texts in Computer Science, Springer.
4) Michael Sipser, Introduction to the Theory of Computation, PWS Publishing.
5) John Martin, Introduction to Languages and The Theory of Computation, Tata McGraw Hill

CS20202	**Software Engineering**	3-0-0	3 Credits

- Intro, Recap of C, C and C++
- Constants and inline functions, Reference and pointers, Default Parameters & Function Overloading, Operator overloading
- Dynamic Memory Management, Classes and objects, Access specifiers
- Constructor, destructor, object lifetime, Copy Constructor and Copy Assignment Operator, Const-ness
- Static Members, Friend Function and friend Class, Operator overloading for user defined types
- Operator overloading, Namespaces, Inheritence
- Inheritence (Example + Private/Protected), Polymorphism (Type casting + Static / Dynamic Binding + Pure Virtual Function)
- Virtual Function Table, Type Casting (const_cast,static_cast,reinterpret_cast,dynamic_cast), Exceptions
- Function Templates, Class templates, Functors
- SDLC: Goals, Benefits, Stages, Models - waterfall, v-shaped, Spiral, Agile, UML Diagrams
- Software Testing

References:

1) Roger S Pressman, Software Engineering: A Practitioner's Approach, 7th Edition, McGraw Hill Education,2009.
2) Rajib Mall, Fundamentals of Software Engineering, Prentice Hall India, 2014
3) Bjarne Stroustrup, The C++ Programming Language, 4th Edition, Addison-Wesley, 2013
4) Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides, Design Patterns: Elements of Reusable Object-Oriented Software, Addison Wesley, 1994

CS29202	**Software Engineering Laboratory**	0-0-3	2 Credits

CS21202	**Switching Circuits and Logic Design**	3-1-0	4 Credits

- Logic families: TTL, nMOS, CMOS, dynamic CMOS and pass transistor logic (PTL) circuits, inverters and other logic gates, area, power and delay characteristics, concepts of fan-in, fan-out and noise margin.
- Switching theory: Boolean algebra, logic gates, and switching functions, truth tables and switching expressions, minimization of completely and incompletely specified switching functions, Karnaugh map and Quine-McCluskey method, multiple output minimization, representation and manipulation of functions using BDDs, two-level and multi-level logic circuit synthesis.
- Combinational logic circuits: Realization of Boolean functions using NAND/NOR gates, Decoders, multiplexers. logic design using ROMs, PLAs and FPGAs. Case studies.
- Sequential circuits: Clocks, flip-flops, latches, counters and shift registers, finite-state machine model, synthesis of synchronous sequential circuits, minimization and state assignment, asynchronous sequential circuit synthesis.
- ASM charts: Representation of sequential circuits using ASM charts, synthesis of output and next state functions, data path control path partition-based design.

CS29204	**Switching Circuits Laboratory**	0-0-3	2 Credits

1) Half Adder, Full Adder and Ripple Carry Adder/Subtract
2) Combinational BCD to binary by double-dabble method
3) 1-bit Hamming ECC
4) Carry Look Ahead Adder
5) Block Carry Look Ahead Adder
6) Comparator
7) Shift Register and LFSR
8) Barrel Shift Register
9) Synchronous counter

CS29206	**Systems Programming Laboratory**	0-0-3	2 Credits

- [Lab 1]: Introduction to the course, writing makefiles, using gcc/clang (3 hours)
- [Lab 2]: Introduction to code debugging, understanding code debugging with gdb (3 hours)
- [Lab 3]: Code profiling using gprof, finding inefficiencies and performance bottlenecks in code, optimizing code performance (3 hours)
- [Lab 4]: Memory profiling, debugging, and management using valgrind (3 hours)
- [Lab 5]: Setting up and using version control systems (3 hours)
- [Lab 6-7]: Unix-based commands for system management, file processing, pipes, regular expressions and text processing using grep, sed, and awk (6 hours)
- [Lab 8-9]: Unix shells and shell scripting (6 hours)
- [Lab 10-11]: Introduction to linking and loading programs, Binary file formats - Executable and Linkable File Formats (ELF), analyzing the hexdump of a binary file for analyzing program headers (6 hours)
- [Lab 12-13] System configuration and management (6 hours)

EA10010	**Extra Academic Activity-IV**	0-0-3	1 Credits

1) Natural Cultural Appreciation (NCA)
2) National Cadet Corps (NCC)
3) National Service Scheme (NSS)
4) Health and Fitness
5) NSO (Sports and Games)

BE1	**Breadth Elective 1**		

HSSE1	**Humanities and Social Science Elective 1**		

Semester 5

CS31005	**Algorithms-II**	3-1-0	4 Credits

- Models of computation: RAM model and its logarithmic cost.
- Formal introduction to algorithmic paradigms: divide and conquer, recursion, dynamic programming, greedy, branch and bound, etc.
- Advanced data structures: Fibonacci heap, unionfind, splay trees.Amortized complexity analysis
- Randomized algorithms: Randomized algorithms to be introduced a bit early, i.e. before NP completeness to highlight randomization as an algorithmic technique. Application areas:
  1) Geometric algorithms: convex hulls, nearest neighbor, Voronoi diagram, etc.
  2) Algebraic and number-theoretic algorithms: FFT, primality testing, etc.
  3) Graph algorithms: network flows, matching, etc.
  4) Optimization techniques: linear programming
- Reducibility between problems and NP-completeness: discussion of different NP-complete problems like satisfiability, clique, vertex cover, independent set, Hamiltonian cycle, TSP, knapsack, set cover, bin packing, etc. Backtracking, branch-and-bound.
- Approximation algorithms: Constant ratio approximation algorithms.
- Miscellaneous: Introduction to external memory algorithms, parallel algorithms.

References

1) Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press.
2) Allan Borodin, Ran El-Yaniv, Online Computation and Competitive Analysis, Cambridge University Press.
3) Nancy Lynch, Distributed Algorithms, Morgan Kaufmann.
4) Robert Endre Tarjan, Data Structures and Network Algorithms, SIAM.
5) L. Grotchel, L. Lovasz, and A. Schrijver, Geometric algorithms and Combinatorial Optimization, Springer.
6) M. Kearns and U. Vazirani, An Introduction to Computational Learning Theory. MIT Press.
7) N. Alon and J. H. Spencer, The Probabilistic Method, John Wiley.
8) Vijay Vazirani, Approximation Algorithms, Springer.
9) Fan Chung, Spectral Graph Theory, American Mathematical Society.

CS31007	**Computer Organisation and Architecture**	3-1-0	4 Credits

- **Basic functional blocks of a computer**: CPU, memory, input-output subsystems, control unit. Instruction set architecture of a CPU - registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set. Case study - instruction sets of some common CPUs.
- **Data representation**: signed number representation, fixed and floating point representations, character representation. Computer arithmetic - integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication - shift-and-add, Booth multiplier, carry save multiplier, etc. Division - restoring and non-restoring techniques, floating point arithmetic.
- **CPU control unit design**: hardwired and micro-programmed design approaches, Case study - design of a simple hypothetical CPU.
- **Memory system design**: semiconductor memory technologies, memory organization.
- **Peripheral devices and their characteristics**: Input-output subsystems, I/O transfers - program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes - role of interrupts in process state transitions.
- **Performance enhancement techniques**: Pipelining: Basic concepts of pipelining, throughput and speedup, pipeline hazards.
- **Memory organization**: Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs. block size, mapping functions, replacement algorithms, write policies.

CS39001	**Computer Organisation Laboratory**	0-0-6	4 Credits

1) Familiarization with assembly language programming.
2) Synthesis / design of simple data paths and controllers, processor design.
3) Interfacing with CPU DAC, ADC, keyboard-display modules, etc.

Development kits as well as Microprocessors/PCs may be used for the laboratory, along with design/ simulation tools as and when necessary.

References

1) David A. Patterson and John L. Hennessy, Computer Organization and Design: The Hardware/ Software Interface, Elsevier.
2) Carl Hamachar, Zvonco Vranesic and Safwat Zaky, Computer Organization, McGraw Hill.
3) John P. Hayes, Computer Architecture and Organization, McGraw Hill.
4) William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson Education.
5) Vincent P. Heuring and Harry F. Jordan, Computer Systems Design and Architecture, Pearson Education.

CS31003	**Compilers**	3-0-0	3 Credits

The aim is to learn how to design and implement a compiler and also to study the underlying theories. The main emphasis is for the imperative language.

- Introduction: Phases of compilation and overview.
- Lexical Analysis (scanner): Regular languages, finite automata, regular expressions, from regular expressions to finite automata, scanner generator (lex, flex).
- Syntax Analysis (Parser): Context-free languages and grammars, push-down automata, LL(1) grammars and top-down parsing, operator grammars, LR(O), SLR(1), LR(1), LALR(1) grammars and bottom-up parsing, ambiguity and LR parsing, LALR(1) parser generator (yacc, bison)
- Semantic Analysis: Attribute grammars, syntax directed definition, evaluation and flow of attribute in a syntax tree.
- Symbol Table: Its structure, symbol attributes and management.
- Run-time environment: Procedure activation, parameter passing, value return, memory allocation, and scope.
- Intermediate Code Generation: Translation of different language features, different types of intermediate forms.
- Code Improvement (optimization): Analysis: control-flow, data-flow dependence etc.; Code improvement local optimization, global optimization, loop optimization, peep-hole optimization etc. Architecture dependent code improvement: instruction scheduling (for pipeline), loop optimization (for cache memory) etc.
- Register allocation and target code generation
- Advanced topics: Type systems, data abstraction, compilation of Object Oriented features and non-imperative programming languages.

CS39003	**Compilers Laboratory**	0-0-3	2 Credits

The aim is to write a compiler for a small language.
Familiarity with compiled codes (assembly language) of RISC and CISC machines, writing a scanner, writing a predictive parser for a small language, a small experiment with scanner (lex/flex) and parser (yacc/byson) generator (such as translation of regular expressions to NFA or the construction of parse tree), writing scannerparse specification for a small language, translation of the language to an intermediate form (e.g. three-address code), generation of target code (in assembly language). Code improvement (optional).

References

1) Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques and Tools, AddisonWesley.

2) Michael L. Scott, Programming Language Pragmatics, Elsevier.
3) Andrew W. Appel, Modern Compiler Implementation in C/Java, Cambridge University Press.
4) Keith D. Cooper and Linda Torczon, Engineering a Compiler, Elsevier.
5) Allen I. Holob, Compiler Design in C, Prentice-Hall.
6) Steven S. Muchnik, Advanced Compiler Design and Implementation, Elsevier.
7) Randy Allen and Ken Kennedy, Optimizing Compilers for Modern Architectures, Elsevier.
8) Santanu Chattopadhyay, Compiler Design, Prentice Hall of India Pvt. Ltd.

BE2	**Breadth Elective 2**		

DE1	**Depth Elective 1**		

Semester 6

CS30202	**Database Management Systems**	3-0-0	3 Credits

Pre-requisites: Discrete Structures (CS21201)

- Database system architecture: Data Abstraction, Data Independence, Data Definition and Data Manipulation Languages.
- Data models: Entity-relationship, relational and object oriented data models, integrity constraints and data manipulation operations.
- Relational query languages: Relational algebra, tuple and domain relational calculus, SQL.
- Relational database design: Domain and data dependency, Armstrong axioms, normal forms, dependency preservation, lossless design.
- Query processing and optimization: Evaluation of relational algebra expressions, query equivalence, join strategies, query optimization algorithms.
- Storage strategies: Indices, B-trees, hashing.
- Transaction processing: Recovery and concurrency control, locking and timestamp based schedulers, multiversion and optimistic concurrency control schemes. A
- Advanced topics: Objectoriented and object relational databases, logical databases, web databases, distributed databases, data warehousing and data mining.

Reference Books:

1) Abraham Silberschatz, Henry Korth, and S. Sudarshan, Database System Concepts, McGraw Hill.
2) Raghu Ramakrishnan, Database Management Systems, WCB/McGraw Hill.
3) Bipin Desai, An Introduction to Database Systems, Galgotia.
4) J. D. Ullman, Principles of Database Systems, Galgotia.
5) R. Elmasri and S. Navathe, Fundamentals of Database Systems, Addison-Wesley.
6) Serge Abiteboul, Richard Hull and Victor Vianu, Foundations of Databases. AddisonWesley.

CS39202	**Database Management Systems Laboratory**	0-0-3	2 Credits

Pre-requisites: Discrete Structures (CS21201)

Database schema design, database creation, SQL programming and report generation using a commercial RDBMS like ORACLE/SYBASE/DB2/SQLServer/INFORMIX. Students are to be exposed to front end development tools, ODBC and CORBA calls from application Programs, internet based access to databases and database administration.

1) Entity Relationship Model and Relational Database Design
2) Structured Query Language (SQL)
3) Advanced SQL
4) Data Warehousing
5) Web Application Development
6) Smartphone Application development

Reference Books: same as above

CS31202	**Operating Systems**	3-1-0	4 Credits

Prerequisites: Computer Organisation and Architecture (CS31007)
Introduction to OS; Concept of process, states and state transition; Scheduling algorithms, context switching; Process synchronization and inter-process communication; Threads, popular thread libraries, thread synchronization; Deadlock: necessary conditions, avoidance and prevention; Memory management: Contiguous and non-contiguous allocation, physical and logical addresses, paging, virtual memory; File systems: file operations, organization, mounting, sharing; File system implementation; Disk and I/O management; Virtualization: motivation and techniques; Case studies of operating systems.

Reference Books:
1) Operating Systems Concepts, by Abraham Silberschatz, Peter B. Galvin, and Greg Gagne, Wiley India, 2018 or later
2) Modern Operating Systems, 4th edition, by Andrew Tanenbaum and Herveart Bos, Pearson, 2015 or later
3) Operating Systems: Three Easy Pieces, by Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau, Arpaci-Dusseau Books LLC, 2018

CS39002	**Operating Systems Laboratory**	0-0-3	2 Credits

Familiarization with UNIX system calls for process management and inter-process communication; Experiments on process scheduling and other operating system tasks through simulation/ implementation under a simulated environment (like Nachos).

References
1) Avi Silberschatz, Peter Galvin, Greg Gagne, Operating System Concepts, Wiley Asia Student Edition.
2) William Stallings, Operating Systems: Internals and Design Principles, Prentice Hall of India.
3) D. M. Dhamdhere, Operating Systems: A Concept-Based Approach, Tata McGrawHill.
4) Charles Crowley, Operating System: A Design-oriented Approach, Irwin Publishing.
5) Gary J. Nutt, Operating Systems: A Modern Perspective, Addison-Wesley.
6) Maurice Bach, Design of the Unix Operating Systems, Prentice-Hall of India.
7) Daniel P. Bovet, Marco Cesati, Understanding the Linux Kernel, O Reilly and Associates.

CS31204	**Computer Networks**	3-1-0	4 Credits

Introduction to networks and layered architecture. Basics of data communication: transmission media and topology, data encoding techniques, error control, flow control, multiplexing techniques. Medium access control: CSMA, CSMA/CD. Local Area Networks and Ethernet. Basics of circuit switching and packet switching. Routing protocols: distance vector and link state routing. IPv4: addresses, subnet, routing table and its use, route aggregation, RIP and OSPF, fragmentation, ICMP, ARP. Basics of IPv6. TCP: properties, connection establishment and termination, data transfer, flow control, congestion control. UDP, DNS, DHCP, case study of application layer protocols. Internet architecture and routing: physical interconnection, autonomous systems, BGP. Basics of wireless networks.

Reference Books:
1) Data and Computer communication, 10th Edition, by William Stallings, Pearson Education, 2017
2) Data Communication and Networking, 5th Edition, by Behrouz A. Forouzan, McGraw Hill, 2017
3) Internetworking with TCP/IP, Volume 1, by Douglas Comer, Person, 2013
4) TCP/IP Protocol Suite, 4th Edition, by Behrouz Forouzan, McGraw Hill, 2017
5) Computer Networking: a Top-down Approach, 7th Edition, by James Kurouse and Keith Ross, Pearson, 2017

CS39006	**Networks Lab**	0-0-3	2 Credits

Simulation experiments for protocol performance, configuring, testing and measuring network devices and parameters/policies; network management experiments; Exercises in network programming.

References

1) William Stallings, Data and Computer Communication, Prentice Hall of India.
2) Behrouz A. Forouzan, Data Communication and Networking, McGraw-Hill.
3) Andrew S. Tanenbaum, Computer Networks, Prentice Hall.4.Douglas Comer, Internetworking with TCP/IP, Volume 1, Prentice Hall of India.
5) W. Richard Stevens, TCP/IP Illustrated, Volume 1, Addison-Wesley.

DE2	**Depth Elective 2**		

Semester 7

CS48003	**Summer Training**		
DBE1	**Depth/Breadth Elective 1**		
DBE2	**Depth/Breadth Elective 2**		
DE3	**Depth Elective 3**		
DE4	**Depth Elective 4**		
PROJ1	**Project 1**		

Semester 8

DBE3	**Depth/Breadth Elective 3**		
DBE4	**Depth/Breadth Elective 4**		
DE5	**Depth Elective 5**		
PROJ2	**Project 2**		