Course structure of B. Tech. AI &DS-2021, IIT Patna

Semester	Course Code	Course name	L-T-P-Credit	Offering Department
Semester I	CE111	Engineering Drawing	1-0-3-5	Civil
	EE101	Electrical Sciences	3-1-0-8	Electrical
	HS103	Communicative English for Engineers	2-0.5-1-6	Humanities and Social Science
	MA101	Mathematics I	3-1-0-8	Mathematics
	ME110	Workshop-I	0-0-3-3	Mechanical
	PH103	Physics –I	3-1-0-8	Physics
	PH 110	Physics Laboratory	0-0-3-3	Physics
	NSS/NSO/Cultural	NSS/NSO/Cultural	P/NP	
			Total credits: 41	
Semester II	CB102&CE102	Biology and Environmental Studies	3-0-0-6	CB & CE
	CH103	Introductory Chemistry	3-1-0-8	Chemistry
	CH110	Chemistry Laboratory	0-0-3-3	Chemistry
	CS102	Programming and Data Structures	3-0-0-6	CS
	CS112	Programming and Data Structures Laboratory	0-0-3-3	CS
	EE103	Basic Electronics Laboratory	0-0-3-3	EE
	MA102	Mathematics –II	3-1-0-8	Mathematics
	ME102	Engineering Mechanics	3-1-0-8	ME
	NSS/NSO/Cultural	NSS/NSO/Cultural	P/NP	
			Total credits: 45	
Semester III	MA316	Mathematical Statistics	3-0-0-6	Mathematics
	HS2XX	HSS Elective – I	3-0-0-6	Humanities and Social Science
	CS204	Algorithms	3-0-0-6	CS
	CS224	Algorithms Laboratory	0-0-3-3	CS
	CS234	Linear Algebra for Data Science	3-0-0-6	CS
	CS209	Computer Architecture	3-0-0-6	CS

	CS210	Computer Architecture Lab	0-0-3-3	CS
	CS271	Optimization techniques	3-0-0-6	CS
	CS230	Software Lab/Tools	0-0-3-3	CS
			Total credits: 45	
Semester IV	HS2XX	HSS Elective – II	3-0-0-6	Humanities and Social Science
	MA225	Prob. Theory and Random Processes	3-0-0-6	Mathematics
	CS249	Artificial Intelligence -I	3-0-0-6	CS
	CS250	Artificial Intelligence Lab	0-0-3-3	CS
	CS259	Database	3-0-0-6	CS
	CS260	Database Lab	0-0-3-3	CS
	CS267	Theory of computation	3-0-0-6	CS
	CS277	Machine Learning & DS	3-0-0-6	CS
			Total credits: 42	
Semester V	XX3XX	Open Elective	3-0-0-6	Science/Engg.
	CS341	Operating Systems	3-0-0-6	CS
	CS340	Operating Systems Lab	0-0-3-3	CS
	CS358	Computer Network	3-0-0-6	CS
	CS359	Computer Network Lab	0-0-3-3	CS
	CS365	Deep Learning	3-0-0-6	CS
	CS389	Innovative Design Lab	0-0-3-3	CS
	CS349	Artificial Intelligence-II	3-0-0-6	CS
			Total credits: 39	
Semester VI	HS3XX	HSS Elective – III	3-0-0-6	Humanities and Social Science
	CS379	Advance Machine Learning	3-0-0-6	CS
	CS375	Bayesian Data Analysis	3-0-0-6	CS
	CS380	Programming for AI/ML	0-0-3-3	CS
	CS385	Computer Vision	2-0-2-6	CS
	CS397	Capstone Project-I	0-0-3-3	CS
			Total credits: 30	

Semester VII	XX4XX	Open Elective	3-0-0-6	
	CS411	Deep Learning for Natural Language Processing	3-0-0-6	CS
	CS431	Bigdata Analytics	2-0-2-6	CS
	CS4XX	Elective – I	3-0-0-6	CS
	CS4xx	Elective – II	3-0-0-6	CS
	CS497	Capstone Project-II	0-0-3-3	CS
			Total credits: 33	
Semester VIII	CS457	Bigdata Security	2-0-2-6	CS
	xx4XX	Elective- III	3-0-0-6	
	xx4XX	Elective-IV	3-0-0-6	
	CS482	individual Project	3-0-0-6	CS
			Total credits: 24	

Proposed Electives

Database & Data Mining
Introduction to Computational Topology
Geometric and Topological Modelling for Scientists and Engineers
Mobile Robotics
Cloud Computing
Statistical signal processing
Estimation and Detection
information theory and coding
Introduction to Network Science
Cryptography
High Performance Computing
Social Text Mining,
AI in Healthcare
Conversational AI
Discrete Differential Geometry
Computational Geometry
Topological Data Analysis
Planning Algorithms,
A Mathematical Introduction to Robotics
Advanced Signal Processing for AI and DS
Edge AI
Statistical signal processing,
Estimation and Detection,
Applications of artificial intelligence in Chemistry
Graph Representation Learning,
Advanced Network Science,
Distributed Machine Learning
Deep Learning for NLP
Conversational Artificial Intelligence,
Machine Translation,
Information Retrieval and Mining,

	Sentiment and Emotion Analysis Advanced Operating Systems Signal Processing and Machine Learning for Data Science Applied Time Series Analysis Probability and Random Process Applied Time Series Analysis Reinforcement Learning	

Total credits: 299

Detailed Syllabus

Semester I

CE111	Engineering Drawing	1-0-3-5	Civil

Geometrical construction of simple plane figure: Bisecting the line, draw perpendicular, parallel line, bisect angle, trisect angle, construct equatorial triangle, square, polygon, inscribed circle.

Free hand sketching: prerequisites for freehand sketching, sketching of regular and irregular figures.

Drawing scales: Engineering scale, graphical scale, plane scale, diagonal scale, comparative scale, scale of chord.

Orthographic projection: Principle of projection, method of projection, orthographic projection, plane of projection, first angle of projection, third angle of projection, reference line.

Projection of points, lines and plane: A point is situated in the first quadrant, point is situated in the second quadrant, point is situated in the third quadrant, point is situated in the fourth quadrant, projection of line parallel to both the plane, line contained by one or both the plane, line perpendicular to one of the plane, line inclined to one plane and parallel to other, line inclined to both the plane, true length of line.

Missing views: Drawing of missing front view of a solid, missing top view of solids, missing side view of solids, Orthographic projection of simple solid: Introduction, types of solid, projection of solid when axis perpendicular to HP, axis perpendicular to VP, axis parallel to both HP and VP, axis inclined to both HP and VP.

Orthographic projection of simple solid: Introduction, types of solid, projection of solid when axis perpendicular to HP, axis perpendicular to VP, axis parallel to both HP and VP, axis inclined to both HP and VP.

Text and Reference Books:

1. B. Agrawal and CM Agrawal, Engineering Drawing, Tata McGraw-Hill Publishing Company Limited, 2008.
2. D. A. Jolhe, Engineering Drawing, Tata McGraw-Hill Publishing Company Limited, 2006.
3. K. Venugopal, Engineering Drawing and Graphics, 2nd ed., New Age International, 1994.

EE101	Electrical Sciences	3-1-0-8	Electrical

Circuit Analysis Techniques, Circuit elements, Simple RL and RC Circuits, Kirchhoff's law, Nodal Analysis, Mesh Analysis, Linearity and Superposition, Source Transformations, Thevnin's and Norton's Theorems, Time Domain Response of RC, RL and RLC circuits, Sinusoidal Forcing Function, Phasor Relationship for R, L and C, Impedance and Admittance.

Semiconductor Diode, Zener Diode, Rectifier Circuits, Clipper, Clamper, Bipolar Junction Transistors, Transistor Biasing, Transistor Small Signal Analysis, Transistor Amplifier, Operational Amplifiers, Op-amp Equivalent Circuit, Practical Op-amp Circuits, DC Offset, Constant Gain Multiplier, Voltage Summing, Voltage Buffer, Controlled Sources, Instrumentation Circuits, Active Filters and Oscillators.

Number Systems, Logic Gates, Boolean Theorem, Algebraic Simplification, K-map, Combinatorial Circuits, Encoder, Decoder, Combinatorial Circuit Design, Introduction to Sequential Circuits.
Magnetic Circuits, Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, Analysis of Three-Phase Circuits, Electromechanical Energy Conversion, Introduction to Rotating Machines.

Text and Reference Books:

1. C. K. Alexander and M. N. O. Sadiku, Fundamentals of Electric Circuits, 3rd Edition, McGraw-Hill, 2008.
2. W. H. Hayt and J. E. Kemmerly, Engineering Circuit Analysis, McGraw-Hill, 1993.
3. Donald A Neamen, Electronic Circuits; analysis and Design, 3rd Edition, Tata McGraw-Hill Publishing Company Limited.
4. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004.
5. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 6th Edition, PHI, 2001.
6. M. M. Mano, M. D. Ciletti, Digital Design, 4th Edition, Pearson Education, 2008.
7. Floyd and Jain, Digital Fundamentals, 8th Edition, Pearson.
8. A. E. Fitzgerald, C. Kingsley Jr. and S. D. Umans, Electric Machinery, 6th Edition, Tata McGraw-Hill, 2003.
9. D. P. Kothari and I. J. Nagrath, Electric Machines, 3rd Edition, McGraw-Hill, 2004.

HS103	Communicative English for Engineers	2-0.5-1-6	HSS

In today's 'global village', there are many who believe that 'Communication is like breathing and life would cease to continue without it'. This particular course on communication skills imbibes the same and therefore, it aims to equip the students with getting the basics right of communication and presentation skills for academic and professional purposes. It is designed to help the second language learners acquire fluency in both spoken and written English to communicate information with clarity, precision and confidence especially in the professional sphere. It will introduce learners not only to the basic concepts in communication but also focus on providing them a hands-on experience of the same. It is hoped that after commanding the skills required in spoken and written English, learners will be able to express themselves more effectively.
The course will have ten units and shall focus on the following topics:

Unit 1: Language and Communication
What is Communication
Nature, Style and Process of Communication
Communication Barriers
Objectives and Importance of Communication
Formal and Informal Communication
Verbal and Non-Verbal Communication

Unit 2: English Language Remedial Skills
Construction of Sentences
Subject-Verb Agreement

Tenses
Active and Passive Voice
Direct and Indirect Speech
Common Errors

Unit 3: Oral Skills
Public Speaking
Dealing with lack of confidence
Making an Effective Presentation
Telephone Etiquette
Understanding GD
Why conduct a GD?
How to gear up for a GD?
Different Phases of GD

Unit 4: Listening Skills
Meaning of Listening
Different Types of Listening
Barriers to Listening and Methods to overcome them
Various strategies to develop effective Listening
Semantic Markers

Unit 5: Reading Skills
What is Reading?
Types of Reading
Reading Comprehension

Unit 6: Writing Skills
Business Correspondence
Element and Style of Writing
Report Writing
Notice, Agenda and Minutes

Unit 7: Interview Techniques
How to prepare for an Interview
An Interview

Text and Reference Books:

1. V. S. Kumar, P.K. Dutt and G. Rajeevan, A Course in Listening and Speaking-I, Foundation books, 2007.
2. V.Sasikumar, P.KiranmaiDutt, Geetha Rajeevan, "A Course in Listening and Speaking-II', Foundation books, 2007.
3. Rizvi, Ashraf, Effective Technical Communication, Tata McGraw Hill, 2005.
4. Nitin Bhatnagar and MamtaBhatnagar, 'Communicative English for Engineers and Professionals, Pearson, 2010.

MA101	Mathematics I	3-1-0-8	Mathematics

Properties of real numbers. Sequences of real numbers, montone sequences, Cauchy sequences, divergent sequences. Series of real numbers, Cauchy's criterion, tests for

convergence. Limits of functions, continuous functions, uniform continuity, montoneand inverse functions. Differentiable functions, Rolle's theorem, mean value theorems and Taylor's theorem, power series. Riemann integration, fundamental theorem of integral calculus, improper integrals. Application to length, area, volume, surface area of revolution. Vector functions of one variable and their derivatives. Functions of several variables, partial derivatives, chain rule, gradient and directional derivative. Tangent planes and normals. Maxima, minima, saddle points, Lagrange multipliers, exact differentials. Repeated and multiple integrals with application to volume, surface area, moments of inertia. Change of variables. Vector fields, line and surface integrals. Green's, Gauss' and Stokes' theorems and their applications.

Text Books:

1. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, 6th Ed/9th Ed, Narosa/ Addison Wesley/ Pearson, 1985/ 1996.
2. T. M. Apostol, Calculus, Volume I, 2nd Ed, Wiley, 1967. T. M. Apostol, Calculus, Volume II, 2nd Ed, Wiley, 1969.

Reference Books:

1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 5th Ed, Wiley, 1999.
2. J. Stewart, Calculus: Early Transcendentals, 5th Ed, Thomas Learning (Brooks/ Cole), Indian Reprint, 2003.

ME110	Workshop-I	0-0-3-3	Mechanical

Sheet Metal Working:

Sheet material: GI sheets, aluminium, tin plate, copper, brass etc.; Tools: steel rule, Vernier calipers, micrometer, sheet metal gauge, scriber, divider, punches, chisels, hammers, snips, pliers, stakes etc.; operations: scribing, bending, shearing, punching etc.; Product development: hexagonal box with cap, funnel etc.

Pattern Making and Foundry Practice:

Pattern material: wood, cast iron, brass, aluminium, waxes etc.; Types of patterns: split, single piece, match plate etc.; Tools: cope, drag, core, core prints, shovel, riddle, rammer, trowel, slick, lifter, sprue pin, bellow, mallet, vent rod, furnace etc. Moulding sands: green sand, dry sand, loam sand, facing sand etc., Sand casting: Sand preparation, mould making, melting, pouring, and cleaning. Joining:

Classifications of joining processes; Introduction to Arc welding processes; power source; electrodes; edge preparation by using tools bench vice, chisels, flat file, square file, half round file, round file, knife edge file, scrapers, hacksaws, try squares; cleaning of job, Job: lap and butt joints using manual arc welding.

Machining Centre:

Introduction to different machine tools; Working principle of lathe, milling, drilling etc.; Setting and preparation of job using lathe and milling; Performing different operations namely, straight turning, taper turning, knurling, thread cutting etc.; Introduction to dividing head, indexing, performing operation in milling using indexing mechanism.

CNC Centre:

Introduction to CNC machines; Fundamentals of CNC programming using G and M code; setting and operations of job using CNC lathe and milling, tool reference, work reference, tool offset, tool radius compensation.

Text and Reference Books:

1. H. Choudhury, H. Choudhary and N. Roy, Elements of Workshop Technology, vol. I,Mediapromoters and Publishers Pvt. Ltd., 2007.

2. W. A. J. Chapman, Workshop Technology, Part -1, 1st South Asian Edition, Viva Book Pvt Ltd., 1998.
3. P.N. Rao, Manufacturing Technology, Vol.1, 3rd Ed., Tata McGraw Hill PublishingCompany, 2009.
4. B.S. Pabla, M.Adithan, CNC machines,New Age International, 2012.
5. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, 6th Ed/9th Ed, Narosa/Addison Wesley/Pearson, 1985/1996.
6. T. M. Apostol, Calculus, Volume I, 2nd Ed, Wiley, T. M. Apostol, Calculus, Volume II, 2nd Ed, Wiley, 1969/1967.

PH103	Physics-I	3–1–0–8	PH

Orthogonal coordinate systems and frames of reference, conservative and non-conservative forces, work-energy theorem, potential energy and concept of equilibrium; Rotation about fixed axis, translational-rotational motion, vector nature of angular velocity, rigid body rotation and its applications, Euler's equations; Gyroscopic motion and its application; Accelerated frame of reference, centrifugal and Coriolis forces.

Harmonic oscillator, damped and forced oscillations, resonance, coupled oscillations, small oscillation, normal modes, longitudinal and transverse waves, wave equation, plane waves, phase velocity, superposition wave packets and group velocity, two- and three-dimensional waves.

Failure of classical concepts, Black body radiation, photo-electric effect, Compton effect, Davison and Germer's experiment, Frank-Hertz experiment, Bohr's theory, Sommerfeld's model, correspondence principle, Planck hypothesis, De Broglie's hypothesis, Hilbert space, observables, Dirac notation, principle of superposition, wave packets, phase and group velocities, probability & continuity equation, eigenvalues and Eigen functions, orthonormality, expectation values, uncertainty principle, postulates of Quantum Mechanics, Schrodinger equation & its applications to 1D potentials, field quantization, periodic potential wells: Kronig Penny model and origin of band gap.

Textbooks:

1. D. Kleppner and R. J. Kolenkow, An introduction to Mechanics, Tata McGraw-Hill, New Delhi, 2000.
2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, NY, 2007.
3. Frank S. Crawford, Berkeley Physics Course Vol 3: Waves and Oscillations, McGraw Hill, 1966.
4. Eyvind H. Wichmann, Berkeley Physics Course Vol 4: Quantum physics, McGraw Hill, 1971.

Reference Books:

5. R. P. Feynman, R. B. Leighton and M. Sands, The Feynman Lecture in Physics, Vol I, Narosa Publishing House, New Delhi, 2009.
6. R. P. Feynman, R. B. Leighton and M. Sands, The Feynman Lecture in Physics, Vol III, Narosa Publishing House, New Delhi, 2009.
7. R. Eisberg and R. Resnick, Quantum Physics of atoms, molecules, solids, nuclei and particles, John Wiuley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
8. A. J. Dekker, Solid State Physics, Macmillan Pub. India Ltd., New Delhi, 2009
9. David J. Griffith, Introduction to Quantum Mechanics, Pearson Education Ltd, New Delhi, 2009.

10. B.H. Bransden& C.J. Joachain, Quantum Mechanics, Pearson Education Ltd, New Delhi, 2008.

PH110	Physics Laboratory	0-0-3-3	PH

The list of experiments is as follows:

- Instructions to Students
- Introduction to Error Analysis

Ex 1 Decay of Current in A Capacitive Circuit

Ex 2 Q-Factor of an LCR Circuit

Ex 3 Study of Hall Effect

Ex 4 Speed of Sound in Air

Ex 5 'g' by A Compound Pendulum

Ex 6 Speed of Light in Glass

Ex 7 Determination of e/m

Ex 8 Interference of Light: Newton's Ring

Ex 9 Surface Tension of Water by Method of Capillary Ascent

Ex 10 Determination of Plank's constant by Photoelectric Effect

NSS/NOS/Cultura 1	NSS/NOS/Cultural	P/NP	

Semester II

CB102&CE102	Biology and Environment Studies	3-0-0-6	CB & CE

Module 1 - Biology: 1. Cell – Structure and logic of optimization; 2. Blood – The following tissue – Basis and rationale; 3. Organs – Structure, function, interactions, failure; 4. Molecular basis of disorders – example: Diabetes; 5. Modern techniques of evaluations and corrections; 6. Open discussions – Feedback from students

Module 2 – Environmental Science / Studies: 1.Ecology and Sustainable Development – Ecosystems, Natural cycles, Biodiversity, Man and environment; 2. Water Resources – Hydrologic cycle and its components, Groundwater and surface water, Water quality; 3. Environmental Sanitation: Conventional and ecological sanitation; 4. Environmental Pollution and Control – Air, Water, Soil, Noise Pollution, Solid and Hazardous Waste, Biomedical Waste, E-waste: Sources, effect, treatment and control; 5. Environmental Legislations and Standards; 6.Current Environmental Issues: Greenhouse gases and global warming, Acid rain, Ozone layer depletion, Climate change

Text Books:

1. Any basic Biology Book of CBSE Curriculum at +2 Level/ E-text Books

2. Davis, M.L. and Masten,S.J., Principles of Environmental Engineering and Science,2nd Edition, McGraw-Hill, 2013.
3. Kaushik, A. and Kaushik, C.P., Perspectives in Environmental Studies, 4thEdition, New Age International, 2014.

Reference Books:

4. Botkin,D.B. and Keller,E.A., Environmental Science,8th Edition, Wiley, 2012.
5. Cunningham, W.P. and Cunningham, M.A., Environmental Science: A Global Concern, 13thEdition, McGraw-Hill, 2015

CH103 Introductory Chemistry 3-1-0-8 Chemistry

PHYSICAL CHMEISTRY

Thermodynamics: The fundamental definition and concept, the zeroth and first law. Work, heat, energy and enthalpies. Second law: entropy, free energy and chemical potential. Change of Phase. Third law. Chemical equilibrium, Chemical kinetics: The rate of reaction, elementary reaction and chain reaction.

Electrochemistry: Conductance of solutions, equivalent and molar conductivities and its variation with concentration. Kohlrausch's law-ionic mobilities, Transference number of ions. activities, application of Debye-Huckel theory. The Walden's rule. Debye-Huckel-Onsager treatment. Electrochemical cells, Nernst equation. Application of EMF measurements. Liquid junction potential, commercial cells – the primary and secondary cells. Fuel cells.

INORGANIC CHEMISTRY

Coordination chemistry: ligand, nomenclature, isomerism, stereochemistry, valence bond, crystal field and molecular orbital theories. Bioinorganic chemistry: Trace elements in biology, heme and non-heme oxygen carriers, haemoglobin and myoglobin; organometallic chemistry.

ORGANIC CHEMISTRY

Stereo and regio-chemistry of organic compounds, conformers. Bioorganic chemistry: amino acids, peptides, proteins, enzymes, carbohydrates, nucleic acids and lipids. Modern techniques in structural elucidation of compounds (UV – Vis, IR, NMR). Solid phase synthesis and combinatorial chemistry. Green chemical processes.

Textbooks:

P. W. Atkins, Physical Chemistry, ELBS, 5th Ed, 1994.
J. O'M. Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol. 1 and 2, Kluwer Academic, 2000.
K. L. Kapoor, A Textbook of Physical Chemistry, Macmillan India, 2nd Ed, 1986.
F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, Wiley Eastern Ltd, New Delhi, 3rd Ed, 1972 (reprint in 1998).
D. J. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, ELBS, 2nd Ed, 1994.
S. H. Pine, Organic Chemistry, McGraw Hill, 5th Ed, 1987

Reference Books:

Levine, Physical Chemistry, McGraw Hill, 4th Ed, 1995.

J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principle, structure and reactivity, Harper Collins, 4th Ed, 1993.
L. G. Wade Jr., Organic Chemistry, Prentice Hall, 1987

CH110	Chemistry Laboratory	0-0-3-3	Chemistry

Estimation of metal ion: Determination of total hardness of water by EDTA titration. Experiments based on chromatography: Identification of a mixture containing two organic compounds by TLC. Experiments based on pH metry.: Determination of dissociation constant of weak acids by pH meter. Experiments based on conductivity measurement: Determination of amount of HCl by conductometric titration with NaOH. Synthesis and characterization of inorganic complexes: e.g. Mn(acac)3, Fe(acac)3, cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p. IR etc. Synthesis and characterization of organic compounds: e.g. Dibenzylideneacetone. Kinetics: Acid catalyzed hydrolysis of methyl acetate. Verification of Beer-Lamberts law and determination of amount of iron present in a supplied solution. Experiments based on electro gravimetry and electroplating. Experiments based on magnetometry.

CS102	Programming and Data Structures	3-0-0-6	CS

Introduction to digital computers; introduction to programming- variables, assignments; expressions; input/output; conditionals and branching; iteration; functions; recursion; arrays; introduction to pointers; structures; introduction to data-procedure encapsulation; dynamic allocation; linked structures; introduction to data structures stacks, queues and trees; time and space requirements.

References:

1. B. W. Kernighan and D. Ritchie, The C Programming Language, Prentice Hall of India (2nd Edition).
2. A. Kelley and I. Pohl, A Book on C, Pearson Education (4th Edition).
3. P.J. Deitel and H.M. Deitel , C How To Program, Pearson Education (7th Edition).

CS112	Programing and Data Structures Laboratory	0-0-3-3	CS

Introduction to Unix commands; Introduction to program development tools- vi editor, GNU compiler, testing and debugging, etc.; Implementation of programs in C language.

EE103	Basic Electronics Laboratory	0-0-3-3	EE

Experiments using diodes and bipolar junction transistor (BJT): design and analysis of half -wave and full-wave rectifiers, clipping circuits and Zener regulators, BJT characteristics and BJT amplifiers; experiments using operational amplifiers (op- amps): summing amplifier, comparator, precision rectifier, astable and mono stable multi vibrators and oscillators; experiments using logic gates: combinational circuits such as staircase switch, majority detector, equality detector, multiplexer and demultiplexer; experiments using flip-flops: sequential circuits such as non- overlapping pulse generator, ripple counter, synchronous counter, pulse counter and numerical display.

Reference Books:

1. A. P. Malvino, Electronic Principles. New Delhi: Tata McGraw-Hill, 1993.
2. R. A. Gayakwad, Op-Amps and Linear Integrated Circuits. New Delhi: Prentice Hall of India, 2002.
3. R.J. Tocci: Digital Systems; PHI, 6e, 2001.

MA102	Mathematics-II	3-1-0-8	MA

Linear Algebra: Vector spaces (over the field of real and complex numbers). Systems of linear equations and their solutions. Matrices, determinants, rank and inverse. Linear transformations. Range space and rank, null space and nullity. Eigenvalues and eigenvectors. Similarity transformations. Diagonalization of Hermitian matrices. Bilinear and quadratic forms.

Ordinary Differential Equations: First order ordinary differential equations, exactness and integrating factors. Variation of parameters. Picard's iteration. Ordinary linear differential equations of n-th order, solutions of homogeneous and non-homogeneous equations. Operator method. Method of undetermined coefficients and variation of parameters.

Power series methods for solutions of ordinary differential equations. Legendre equation and Legendre polynomials, Bessel equation and Bessel functions of first and second kind. Systems of ordinary differential equations, phase plane, critical point, stability.

Textbooks:

1. K. Hoffman and R. Kunze, Linear Algebra, Prentice Hall, 1996.
2. T. M. Apostol, Calculus, Volume II, 2nd Ed, Wiley, 1969.
3. S. L. Ross, Differential Equations, 3rd Ed, Wiley, 1984.
4. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall, 1995.
5. W.E. Boyce and R.C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 7th Ed, Wiley, 2001.

Reference Books:

6. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, Wiley, 2005.

ME102	Engineering Mechanics	3-1-0-8	ME

1. Rigid body statics: Equivalent force system. Equations of equilibrium, Freebody diagram, Reaction, Static indeterminacy.

2. Structures: 2D truss, Method of joints, Method of section. Beam, Frame, types ofloading and supports, axial force, Bending moment, Shear force and Torque Diagrams for a member:
3. Friction: Dry friction (static and kinetic), wedge friction, disk friction (thrust bearing), belt friction, square threaded screw, journal bearings, Wheel friction, Rolling resistance.
4. Centroid and Moment of Inertia
5. Virtual work and Energy method: Virtual Displacement, principle of virtual work, mechanical efficiency, work of a force/couple (springs etc.), Potential Energy and equilibrium, stability.
6. Introduction to stress and strain: Definition of Stress, Normal and shear Stress. Relation between stress and strain, Cauchy formula.
7. Stress in an axially loaded member,
8. Stresses due to pure bending,
9. Complementary shear stress,
10. Stresses due to torsion in axi-symmetric sections:
11. Two-dimension state of stress, Mohr's circle representation, Principal stresses

Text and Reference books:

1. I. H. Shames, Engineering Mechanics: Statics and dynamics, 4th Ed, PHI, 2002.
2. F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I - Statics, 3rd Ed, TataMcGraw Hill, 2000.
3. J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol I - Statics, 5th Ed, John Wiley, 2002.
4. E.P. Popov, Engineering Mechanics of Solids, 2nd Ed, PHI, 1998.
5. F. P. Beer and E. R. Johnston, J.T. Dewolf, and D.F. Mazurek, Mechanics of Materials, 6th Ed, McGraw Hill Education (India) Pvt. Ltd., 2012.

NSS/NOS/Cultura 1	**NSS/NOS/Cultural**	**P/NP**

Semester III

MA316	**Mathematical Statistics**	**3–0–0–6**	**MA**

Ordered Statistics, probability distributions of Sample Range, Minimum and Maximum Order Statistics. Random Sampling, Sampling distributions: Chi-square, T, F distributions.

Point Estimation: Sufficiency, Factorization theorem, Consistency, Moment method of estimation, Unbiased Estimation, Minimum Variance Unbiased Estimator and their properties, Rao-Cramer lower bound, Rao-Blackwellization, Fisher Information, Maximum Likelihood Estimator and properties, Criteria for evaluating estimators: Mean squared error.

Interval Estimation: Coverage Probabilities, Confidence level, Sample size determination, Shortest Length interval, Pivotal quantities, interval estimators for various distributions.

Testing of Hypotheses: Null and Alternative Hypotheses, Simple hypothesis, Composite hypothesis, Test Statistic, Critical region, Error Probabilities, Power Function, Level of Significance, Neyman-Pearson Lemma, One- and Two-Sided Tests for Mean, Variance and Proportions, One and Two Sample T-Test, Pooled T-Test, Paired T-Test, Chi-Square Test, Contingency Table Test, Maximum Likelihood Test, Duality between Confidence Intervals.

Bayesian Estimation: Prior and Posterior Distributions, Quadratic Loss Function, Posterior Mean, Bayes Estimates for well Known Distributions (Normal, Gamma, Exponential, Binomial, Poisson, Beta etc.)

Text Books:

1. Mathematical Statistics with applications, Kandethody M. Ramachandran, Chris P. Tsokos, Academic Press.
2. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics
3. Probability and Statistics in Engineering, William W. Hines, Douglas C. Montgomery, David M. Goldsman, John Wiley & Sons, Inc.

Reference Books:

1. Statistical Inference, G. Casella and R.L. Berger, Duxbury Advanced Series.

HS2XX	**HSS Elective – I**	**3–0–0–6**	**HSS**

CS204	**Algorithms**	**3–0–0–6**	**CS**

Asymptotic notations, introduction to complexity (time/space) analysis of algorithms. Basic introduction to algorithmic paradigms like divide and conquer, recursion, greedy, dynamic programming, etc. Searching: binary search trees, balanced binary search trees, AVL trees and red-black trees, B-trees, hashing. Priority queues, heaps, Interval trees. Sorting: quick sort, heap sort, merge sort, radix sort, bucket sort, counting sort, etc. and their analysis. Graph Algorithms: BFS, DFS, connected components, topological sort, minimum spanning trees, shortest paths, network flow. Reducibility between problems and NP-completeness: discussion of different NP-complete problems.

Books

M. A. Weiss, Data Structures and Problem-Solving Using Java, 2nd Ed, Addison-Wesley, 2002.

T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, MIT Press, 2001.

B. W. Kernighan and D. Ritchie, The C Programming Language, 2nd Ed, Prentice Hall of India, 1988.

A. Aho, J. E. Hopcroft and J. D. Ullman, The Design and Analysis of Computer Algorithms, Addison-Wesley, 1974.

S. Sahni, Data Structures, Algorithms and Applications in C++, McGraw-Hill, 2001.

M. T. Goodrich and R. Tamassia, Algorithm Design: Foundations, Analysis and Internet Examples, John Wiley & Sons, 2001.

CS224	Algorithms Laboratory	0–0–3–3	CS

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 topics 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. The lab work can be carried out using any programming language.

CS234	Linear Algebra for Data Science	3–0–0–6	CS

Vectors: addition, scalar multiplication, inner product. Linear functions: linear functions, Taylor approximation and regression model. Clustering: norm, distances, clustering, and the k-means algorithm. Linear independence: linear dependence, basis, orthonormal vectors. Matrices: matrix operations, inverse matrices, simultaneous linear equations, Eigenvalues, and eigenvectors Least squares: least square problem, least square data fitting; the Schur decomposition, spectral expansion, rank-1 expansions. Fundamental theorem of linear algebra, rank-nullity theorem, singular value decomposition. Painter style and motifs, bases for a large dimensional space. Gram-Schmidt algorithm, projection, least squares, data fitting. Data compression, simplification of complex models from structural engineering (reduced-order systems). Discrete Fourier series: diagonal matrices in Fourier basis, applications

Text Books:

Stephen Boyd and Lieven Vandenberghe, Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares (Cambridge University Press, 3rd edition)

Gilbert Strang, Introduction to Linear Algebra (Wellesley Cambridge Press, 5th edition)

CS209	Computer Architecture	3–0–0–6	CS

CPU - registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set. Case study - instruction sets of some common CPUs; Assembly language programming for some processor; Data representation: signed number representation, fixed and floating-point representations, character representation. Computer arithmetic - integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication – shift-and-add, Booth multiplier, carry save multiplier, etc. Division - non-restoring and restoring techniques, floating point arithmetic; CPU control unit design: hardwired and micro-programmed design approaches, Case study - design of a simple hypothetical CPU; Pipelining: Basic concepts of pipelining, throughput and speedup, pipeline hazards; Memory organization: Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs block size, mapping functions, replacement algorithms, write policy; 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.

References:

1. David A. Patterson, John L. Hennessy, Computer Organization and Design, Fourth Edition:
The Hardware/Software Interface, Morgan Kaufmann; 4 edition, 2011.
2. A. Tenenbaum, Structured Computer Organization, 4th Ed, Prentice-Hall of India, 1999.
3. W. Stallings, Computer Organization and Architecture: Designing for Performance, 6th Ed, Prentice Hall, 2005.
4. J. Hennessy and D. Patterson, Computer Architecture A Quantitative Approach, 3rd Ed,
Morgan Kaufmann, 2002.

CS210	Computer Architecture Lab	0-0-3–3	CS

Familiarization with assembly language programming; Synthesis/design of simple data paths and controllers, processor design using HDL like verilog/vhdl; Interfacing - 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.

CS271	Optimization techniques	3–0–0–6	CS

Linear programming: Introduction and Problem formulation, Concept from Geometry, Geo-metrical aspects of LPP, Graphical solutions, Linear programming in standard form, Simplex, Big M and Two-Phase Methods, Revised simplex method, Special cases of LPP.

Duality theory: Dual simplex method, Sensitivity analysis of LP problem, Transportation, Assignment and travelling salesman problem.

Integer programming problems: Branch and bound method, Gomory cutting plane method for all integer and for mixed integer LPP.

Theory of games: saddle point, linear programming formulation of matrix games, two-person zero-sum games with and without saddle-points, pure and mixed strategies, graphical method of solution of a game, solution of a game by simplex method. Computational complexity of the Simplex algorithm, Karmarkar's algorithm for LPP. Acquaintance to softwares like TORA and MATLAB.

Text Books:

1. Hamdy A. Taha, Operations Research: An Introduction, Eighth edition, PHI, New Delhi (2007).
2. S. Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Applications, Narosa Publishing House (2009).
3. A. Ravindran, D.T. Phillips, J.J. Solberg, Operation Research, John Wiley and Sons, New York (2005).
4. M. S. Bazaraa, J. J. Jarvis and H. D. Sherali, Linear Programming and Network Flows, 3rd Edition, Wiley (2004).

Reference Books:

1. D. G. Luenberger, Linear and Nonlinear Programming, 2nd Edition, Kluwer, (2003).
2. S. A. Zenios (editor), Financial Optimization, Cambridge University Press (2002).
3. F. S. Hiller, G. J. Lieberman, Introduction to Operations Research, Eighth edition, McGraw Hill (2006).

CS230	Software Lab/Tools	0–0–3-3	CS

Bash shell programming – basic concepts, expressions, decision making selections, repetition, special parameters - positional parameters, shift, argument validation, script examples.

Android Basics: Getting started with Android development, project folder structure, simple programming, running project, generating build/APK of the app from Android Studio

First application: Creating Android Project, Android Virtual Device Creation, set up debugging environment, Workspace set up for development, launching emulator, debugging on mobile devices. Basic UI design: Basics about Views, Layouts, Drawable Resources, input controls, Input Events etc. Understand the app idea and design user interface/wireframes of mobile app

Set up the mobile app development environment

Semester IV

HS2XX	HSS Elective-II	3-0-0-6	HSS

MA225	Prob Theory and Random Processes	3-0-0-6	MA

Algebra of sets, probability spaces, random variables, cumulative distribution functions, mathematical expectations, conditional probability and expectation, moments and inequalities, special discrete and continuous probability distributions, function of a random variable, random vectors and their distributions, convolutions, joint, marginal and conditional distributions, product moments, independence of random variables, bivariate distributions and properties, order statistics and their distributions, sampling distributions, Central Limit Theorem, strong law of large numbers, sequence of random variables, modes of convergence, distributions of the sample mean and the sample variance for a normal population, chi-square, t and F distributions, method of moments and maximum likelihood estimation, concepts of unbiasedness, criteria for choosing estimators, consistency and efficiency of estimates, confidence intervals, pivotal quantities, confidence intervals for proportions, simple and composite hypothesis, null and alternative hypotheses, types of error, level and size of tests, the most powerful test

and Neyman - Pearson Fundamental Lemma, tests for one- and two-sample problems for normal populations, tests for proportions, likelihood ratio tests, chi-sqaure test for goodness of fit. discrete and continuous stochastic processes, markov chains, transition probability matrix, state spaces, classification of states, stationary distributions, ergodicity, poisson process, birth and death process. Introduction to reliability analysis: Application of Bayes theorem in real life problem; Reliability analysis of simple syste serial, parallel and combined systems; First order uncertainty and reliability analysis (FORM), First order second mom (FOSM) and Advanced FOSM methods; Applications of risk and reliability analysis in engineering systems.

Text / Reference Books:

Scheaffer, R. L., Mulekar, M. S. and McClave, J. T., (2011): Probability and statistics for Engineers, Fifth Edition, Broo Cole, Cengage Learning.
Ang, A. H-S., and Tang, W. H., (2006): Probability Concepts in Engineering, Volumes 1. John Wiley and Sons.
Halder, A and Mahadevan, S., (2000): Probability, Reliability and Statistical Methods in Engineering Design, John Wiley Sons.
Rao, S.S., (1992): Reliability-Based Design, McGraw Hill, Inc.
Harr, M.E., (1987): Reliability-Based Design in Civil Engineering. McGraw Hill, Inc.
Ang, A. H-S, and Tang, W. H., (1975): Probability Concepts in Engineering Planning and Design, Volumes 2. John Wiley and Sons
Benjamin, J., and Cornell. A., (1963): Probability, Statistics, and Decision for Civil Engineers. McGraw Hill.

CS249	Artificial Intelligence-I	3-0-0-6	CS

1.Introduction, Motivation of the course

2. Problem Solving: Uninformed search, Informed search, Local Search,

3. Game Playing: Minmax, Alpha-Beta Pruning, Constraint Satisfaction Problems: Factor Graphs, Backtracking Search, Dynamic Ordering, Arc consistency

4. Knowledge, Reasoning and Planning: Propositional and Predicate Calculus, Semantic Nets,; Automated Planning

5. Machine Learning: Learning from examples and analogy, Naive Bayes, Decision Tree, Introduction to Graphical Models (HMM, MEMM, CRF), Neural Networks

6. Application Topics: Introduction to NLP, Introduction to Fuzzy Sets and Logic

References:

1. S. Russel and P. Norvig. Artificial Intelligence: A Modern Approach (Third Edition), Prentice Hall, 2009
2. E. Rich and K. Knight, Artificial Intelligence, Addison Wesley, 1990
3. T. Mitchel, Machine Learning, McGraw-Hill, 1997

CS250	Artificial Intelligence Lab	0-0-3-3	CS

Small projects based on the concepts and tools taught in AI class.

CS259	Database	3-0-0-6	CS

Database system architecture: Data Abstraction, Data Independence, Data Definition and Data Manipulation Languages; Data models: Entity-relationship, network, relational and object oriented data models, integrity constraints and data manipulation operations; Relational query languages: Relational algebra, tuple and domain relational calculus, SQL and QBE; Relational database design: Domain and data dependency, Armstrongs 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; Recent Trends: XML Data, XML Schema, JSON and "NoSQL Systems, etc.,.

Books:

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

CS260	Database Lab	0-0-3-3	CS

Database schema design, database creation, SQL programming and report generation using a commercial RDBMS like ORACLE/SYBASE/DB2/SQL-Server/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.

CS267	Theory of computation	3-0-0-6	CS

Regular Languages: Finite Automata-Deterministic and Nondeterministic, regular operations, Regular Expressions, Equivalence of DFA, NFA and Res, Nonregular Languages and pumping lemma

Context-Free Languages: Context-Free Grammars, Chomsky Normal Form, Pushdown Automata, Non-Context-Free Languages and pumping lemma, Deterministic Context-Free Languages

Turing Machines: Definition of TM and its variants, Decidability, Reducibility.

Complexity Theory: Time complexity and Space Complexity.

Text Books:

1. Introduction to the Theory of Computation, by Michael Sipser,
2. Computational Complexity, by Christos H. Papadimitriou, Addison-Wesley publishers.

3. Computational Complexity: A Modern Approach, by Sanjeev Arora and Boaz Barak.

CS277	Machine Learning & DS	3-0-0-6	CS

Supervised learning: decision trees, nearest neighbor classifiers, generative classifiers like naive Bayes, linear discriminate analysis, Support vector Machines, feature selection techniques: wrapper and filter approaches, back-ward selection algorithms, forward selection algorithms, PCA, LDA

Unsupervised learning: K-means, hierarchical, EM, K-medoid, DB-Scan, cluster validity indices, similarity measures, some modern techniques of clustering

Graphical models: HMM, CRF, MEMM

Semi-supervised learning

Primary books

1. Pattern recognition and machine learning by Christopher Bishop, Springer Verlag, 2006.

2. Hastie, Tibshirani, Friedman the elements of Statistical Learning Springer Verlag

3. T. Mitchell. Machine Learning. McGraw-Hill, 1997.

Supplementary books

1. Probability, Random Variables and Stochastic processes by Papoulis and Pillai, 4th Edition, Tata McGraw Hill Edition.

2. Linear Algebra and Its Applications by Gilbert Strand. Thompson Books.

3. Data Mining: Concepts and Techniques by Jiawei Han, Micheline Kamber, Morgan Kaufmann Publishers.

4. A. K. Jain and R. C. Dubes. Algorithms for Clustering Data. Prentice Hall, 1988.

Semester V

XX3XX	Open Elective-III	3-0-0-6

CS341	Operating Systems	3-0-0-6	CS

Process Management: process; thread; scheduling. Concurrency: mutual exclusion; synchronization; semaphores; monitors; Deadlocks: characterization; prevention; avoidance; detection. Memory Management: allocation; hardware sup- port; paging; segmentation. Virtual Memory: demand paging; replacement; allocation; thrashing. File Systems and Imple- mentation. Secondary Storage: disk structure; disk scheduling; disk management. (Linux will be used as a running example, while examples will drawn also from Windows NT/7/8.); Advanced Topics: Distributed Systems. Security. Real-Time Systems.

Books:

A. Silberschatz, P. B. Galvin and G. Gagne, Operating System Concepts, 8th Ed, John Wiley & Sons, 2010.
A. S. Tenenbaum, Modern Operating Systems, 2nd Ed, Prentice Hall of India, 2001.
H. M. Deitel, P. J. Deitel and D. R. Choffness, Operating Systems, 3rd Ed, Prentice Hall, 2004.
W. Stallings, Operating Systems: Internal and Design Principles, 5th Ed, Prentice Hall, 2005.
M. J. Bach, The Design of the UNIX Operating System, Prentice Hall of India, 1994.
M. K. McKusick et al, The Design and Implementation of the 4.4 BSD Operating System, Addison Wesley, 1996.

CS340	Operating Systems Lab	0–0–3-3	CS

Programming assignments to build different parts of an OS kernel.

CS358	Computer Network	3-0-0-6	CS

Evolution of computer networks; Physical Layer: Theoretical basis for data communication, transmission media and impairments, switching systems Medium Access Control Sublayer: Channel allocation Problem, multiple access protocols, Ethernet Data link layer: Framing, HDLC, PPP, sliding window protocols, error detection and correction Network Layer: Internet addressing, IP, ARP, ICMP, CIDR, routing algorithms (RIP, OSPF, BGP); Transport Layer: UDP, TCP, flow control, congestion control; Introduction to quality of service; Application Layer: DNS, Web, email, authentication, encryption.

Books:

Peterson & Davie, Computer Networks, A Systems Approach: 5th Edition
William Stallings Data and Computer Communication, Prentice Hall of India.
Behrouz A. Forouzan, Data Communication and Networking, McGraw-Hill.
Andrew S. Tanenbaum, Computer Networks, Prentice Hall.
Douglas Comer, Internetworking with TCP/IP, Volume 1, Prentice Hall of India.
W. Richard Stevens, TCP/IP Illustrated, Volume 1, Addison-Wesley.

CS359	Computer Network Lab	0-0-3-3	CS

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

CS365	Deep Learning	3-0-0-6	CS

This course will provide basic understanding of deep learning and how to solve classification problems having large amount of data. In this course several public domain tools will be demonstrated to build deep learning network.

Course content will be as follows: Brief introduction of big data problem, Overview of linear algebra, probability, numerical computation

- Scalars, vectors, matrix, tensors, norms, Eigen value, eigenvector, singular value decomposition, determinant
- Probability distribution, Bayes rule, conditional probability, variance, covariance
- Overflow, underflow, gradient based optimization, least square

-- Neural network - Perceptron, Multi-level perceptron, Universal approximation theorem

--Tutorial for Tools

- Keras, Theano, TensorFlow
- Demo using MNIST

-- Deep learning network

- Shallow vs Deep network
- Deep feedforward network
- Gradient based learning - Cost function, soft max, sigmoid function
- Hidden unit - ReLU, Logistic sigmoid, hyperbolic tangent
- Architecture design
- Back propagation algorithm - Chain rule of calculus
- SGD

-- Regularization - parameter norm penalties, drop out, noise robustness, early stopping, Batch normalization

-- Optimization for training deep model- Adagrad, Nesterov momentum

-- Advanced topics

- Convolutional Neural Network
- Recurrent Neural Network/ Sequence modeling

-- Practical applications - MNIST, etc.

Books

- Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning"
- Richard S. Sutton & Andrew G. Barto, Reinforcement Learning: An Introduction" (available online)

- Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie, "The elements of statistical learning"

CS389	Innovative Design Lab	0-0-3-3	CS

The objective of this lab would be to encourage and provide support to students for some innovative work. The work may focus on inventing a practical solution for a pure Computer Science or multidisciplinary problems. Depending on the nature of the work, it may be carried out in a group or individual mode.

CS349	Artificial Intelligence-II	3-0-0-6	CSE

Prerequisites: CS249

1. Introduction to the course

2. Knowledge Representation: Ontology, Knowledge Graph, Semantic Web

3, Uncertain Knowledge and Reasoning: Quantifying uncertainty, Probabilistic Reasoning, Probabilistic Reasoning over time, Multi-agent decision making

3. Markov Decision Processes: Policy evaluation, Policy improvement, Policy iteration, Value iteration

4. Reinforcement Learning: Monte Carlo, SARSA, Q-learning, Exploration/Exploitation, Function approximation, Deep reinforcement learning

5. Machine Learning: Clustering, Support Vector Machine, Deep Neural Networks (CNN, RNN, Auto-encoder)

5. Evolutionary Computation: Genetic Algorithm, Ant Colony Optimization, Particle Swarm Optimization, Differential Evolution

6. Conversational AI, Explainable AI, Understanding AI Ethics and Safety

References:

1. S. Russel and P. Norvig. Artificial Intelligence: A Modern Approach (Third Edition), Prentice Hall, 2009
2. E. Rich and K. Knight, Artificial Intelligence, Addison Wesley, 1990
3. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learnng, MIT Press, 2016
4. Daphne Koller and Nir Friedman, Probabilistic Graphical Models: Principles and Techniques, MIT Press, 2009.
5. Sutton and Barto. Reinforcement Learning: An Introduction. Available free online.
6. Hastie, Tibshirani, and Friedman. The elements of statistical learning. Available free online.

Journals and Conference Proceedings:

Artificial Intelligence, Machine Learning, ACL Anthology, COLING, ICML, ECML, Proceedings of Uncertainty in AI, ICCV, ICLR etc.

Semester VI

HS3XX	HSS Elective-III	3-0-0-6	HSS

CS379	Advance Machine Learning	3-0-0-6	CS

Mathematics of machine learning,
Overview of supervised, unsupervised learning and Multi-task learning
• Undirected graphical models: Undirected graphical models: overview, representation of probability distribution and conditional independence statement, Factorization, CRFs, Applications to NLP, Markov networks.
• Directed graphical models: Bayesian networks.

• Deep Networks for Sequence Prediction: Encoder-decoder models (case study translation), Attention models, LSTM, Memory Networks
• Deep Network for Generation – Sequence to Sequence Models – Variational Auto encoders – Generative Adversarial Networks (GANs) – Pointer Generator Networks – Transformer Networks
Learning Representations – Learning representations for text – Word2Vec, FastText, GLOVE, BERT – Learning representations in images based on context prediction (C. Doersch et al. Unsupervised Visual Representation Learning by Context Prediction, ICCV 2015)
Time series forecasting: models and case-studies
Modern clustering techniques: Multi-objective optimization for clustering, Deep learning for clustering Online Learning, Mistake Bounds, Sub-space clustering
Meta-learning and federated learning
Case-studies: Recent topics for solving various problems of natural language processing, bioinformatics, information retrieval

Books:

- Kevin P. Murphy. Machine Learning: A Probabilistic Perspective. MIT Press 2012
- Ian Goodfellow, Yoshua Bengio and Aaron Courville. Deep Learning. MIT Press 2016

Other relevant textbooks:

- Yoav Goldberg. 2016. A primer on neural network models for natural language processing. J. Artif. Int. Res. 57, 1 (September 2016), 345-420.
- R. G. Cowell, A. P. Dawid, S. L. Lauritzen and D. J. Spiegelhalter. "Probabilistic Networks and Expert Systems". Springer-Verlag. 1999.
- M. I. Jordan (ed). "Learning in Graphical Models". MIT Press. 1998.

CS375	Bayesian Data Analysis	3-0-0-6	CS

Introduction: Objective vs Subjective Definition of Probability, Axiomatic Definition of Probability, Bayes Theorem Applications of Bayes Theorem

Decision Theoretic framework and major concepts of Bayesian Analysis Likelihood, Prior and posterior, Loss function, Bayes Rule, Conjugate priors and other priors, Sensitivity Analysis, Posterior Convergence, One-parameter Bayesian models, Poisson Model for Count data, Binomial Model for Count data, Multi-parameter Bayesian models, Univariate Gaussian Model, Multivariate Gaussian Model, Covariance Matrix with Wishart Distribution

Bayesian solution for high-dimensional problem in Covariance matrix for Portfolio Risk Analysis

Multinomial-Dirichlet Allocation Models for Topic Model

Bayesian Machine Learning, Hierarchical Bayesian Model

Regression with Ridge prior, LASSO prior, Classification with Bayesian Logistic Regression, Discriminant Analysis

Bayesian Computation with Stan

Estimation of Posterior Mode with Optimization

Estimation of Posterior Mean and other summary with Monte Carlo Simulation

Accept-Rejection Sampling

Importance Sampling

Markov Chain and Monte Carlo

Metropolis-Hastings

Hamiltonian Monte Carlo

Gaussian Process Regression

Introduction

Gaussian Process Regression for Big Data

Bayesian Optimization

Textbook:

John Kruschke: Doing Bayesian Data Analysis: A Tutorial with R, JAGS, and Stan (2014), Academic Press

Carl Edward Rasmussen and Christopher K. I. Williams: Gaussian Processes for Machine Learning, MIT Press (2006) Available Online

Sourish Das, Sasanka Roy, Rajiv Sambasivan : Fast Gaussian Process Regression for Big Data, Big Data Research, Volume 14, December 2018, Pages 12-26: Preprint Available Here; Python Implementation

CS380	Programming for AI/ML	0-0-3-3	CS

Programming assignments based on tools and techniques taught in ML/DL/AI-II courses. Prolog; Assignment on Logistic regression; Assignment on k-means clustering. Introduction to Tensorflow, Pytorch, Keras.
Usage of Tensorflow, Pytorch and/or Keras: Simple ML examples; Assignments on NNs; Assignments on CNNs; Assignments on RNN; Assignment on LSTM, GRU

References

1.Pytorch: https://pytorch.org/assets/deep-learning/Deep-Learning-with-PyTorch.pdf

2. First Contact with TensorFlow: Get Started with Deep Learning Programming by Jordi Torres

3.https://analyticsindiamag.com/top-10-free-books-and-resources-for-learning-tensorflow/

4. https://keras.io/getting_started/learning_resources/

5. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow (second edition), by Aurélien Géron

CS385	Computer Vision	2-0-2-6	CS

The course will have a comprehensive coverage of theory and computation related to imaging geometry, and scene understanding. It will also provide exposure to clustering, classification and deep learning techniques applied in this area. Camera geometry, Stereo geometry, Stereo Geometry, Feature detection and description Feature matching and model fitting, Color Processing, Range image processing Clustering and classification, Dimensionality Reduction and Sparse Representation Deep Neural Architecture and applications.

CS397	Capstone Project-I	0-0-3-3	CS

The objective of this project would be to encourage and provide support to students for some innovative work. The work may focus on inventing a practical solution for a AI/DS or multidisciplinary problems. Depending on the nature of the work, it may be carried out in a group or individual mode.

Semester VII

XX4XX	Open Elective	3-0-0-6	Science/ Engineering Deptt.

CS411	Deep Learning for Natural Language Processing	3-0-0-6	CS

Natural language processing (NLP) is one of the most important technologies of the information age. Understanding complex language utterances is also a crucial part of artificial intelligence. Applications of NLP are everywhere because people communicate most everything in language: web search, advertisement, emails, customer service, language translation, radiology reports, etc. There are a large variety of underlying tasks and machine learning models powering NLP applications. Recently, deep learning approaches have obtained very high performance across many different NLP tasks. These models can often be trained with a single end-to-end model and do not require traditional, task-specific feature engineering. In this spring quarter course students will learn to implement, train, debug, visualize and invent their own neural network models. The course provides a deep excursion into cutting-edge research in deep learning applied to NLP. The final project will involve training a complex recurrent neural network and applying it to a large scale NLP problem. On the model side we will cover word vector representations, window-based neural networks, recurrent neural networks, long-short-termmemory models, recursive neural networks, convolutional neural networks as well as some very novel models involving a memory component. Through lectures and programming assignments students will learn the necessary engineering tricks for making neural networks work on practical problems

Course Contents:

Intro to NLP

Simple Word Vector representations: word2vec, GloVe: Distributed Representations of Words and Phrases and their Compositionality, [Efficient Estimation of Word Representations in Vector Space

Advanced word vector representations: language models, GloVe: Global Vectors for Word Representation

PoS tagging and named entity recognition

Language modeling and other tasks, Opinion Mining

Parsing, Sentence classification

Machine Translation,

Dynamic Memory Networks

Question Answering, Natural Language Generation and Summarization

Contextual Word Representations: BERT

Text and References:

- Dan Jurafsky and James H. Martin. Speech and Language Processing (3rd ed. draft)
- Jacob Eisenstein. Natural Language Processing
- Yoav Goldberg. A Primer on Neural Network Models for Natural Language Processing
- Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Deep Learning
- Delip Rao and Brian McMahan. Natural Language Processing with PyTorch (requires Stanford login).
- Michael A. Nielsen. Neural Networks and Deep Learning
- Eugene Charniak. Introduction to Deep Learning

Conferences: ACL (Association for Computational Linguistics), EACL (European Association for Computational Linguistics), COLING (International Conference on Computational Linguistics), ICML (International Conference on Machine Learning), IJCNLP (International Joint Conference on Natural Language Processing), AAAI (American Association of Artificial Intelligence), ECAI (European Conference on AI), HLT/NAACl (Human language Technology/ North American Association for Computational Linguistics), ICON (International Conference on Natural Language Processing) etc.

CS431	Big data Analytics	2-0-2-6	CS

Part 1: Introduction to Big Data:

Why Big Data and Where did it come from? Characteristics of Big Data- Volume, Variety, Velocity, Veracity, Valence, Value, Challenges and applications of Big Data
Part 2: Enabling Technologies for Big Data:
Introduction to Big Data Stack, Introduction to some Big Data distribution packages

Part 3: Big Data Computing Technology:
Overview of Apache Spark, HDFS, YARN, Introduction to MapReduce, MapReduce Programming Model with Spark, MapReduce Example: Word Count, Page Rank etc.

Part 4: Big Data Storage Technology:
CAP Theorem, Eventual Consistency, Consistency Trade-Offs, ACID and BASE, Introduction to Zookeeper and Paxos, Introduction to Cassandra, Cassandra Internals, Introduction to HBase, HBase Internals

Part 5: Big Data Analytics framework:
Introduction to Big Data Streaming Systems, Big Data Pipelines for Real-Time computing, Introduction to Spark Streaming, Kafka, Streaming Ecosystem

Part 6: Scalable Machine Learning for Big Data:
Overview of Big Data Machine Learning, Mahout Introduction, Big Data Machine Learning Algorithms in Mahout- kmeans, Naïve Bayes etc.

Part 7: Scalable Machine learning with Spark for Big Data Analytics:
Big Data Machine Learning Algorithms in Spark- Introduction to Spark MLlib, Introduction to Deep Learning for Big Data

Part 8: Large Scale Graph Processing for Big Data:
Introduction to Pregel, Introduction to Giraph, Introduction to Spark GraphX
Laboratory Component: Big Data Analytics Practical sessions on the above topics.

Text Books:
Bart Baesens, Analytics in a Big Data World: The Essential Guide to Data Science and its Applications, Wiley, 2014
Reference Book:
1. Dirk Deroos et al., Hadoop for Dummies, Dreamtech Press, 2014.
2. Chuck Lam, Hadoop in Action, December, 2010 | 336 pages ISBN: 9781935182191
3. Mining of Massive Datasets. Leskovec, Rajaraman, Ullman, Cambridge University Press
4. Data Mining: Practical Machine learning tools and techniques, by I.H. Witten and E. Frank
5. Erik Brynjolfsson et al., The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies, W. W. Norton & Company, 2014

CS4XX	Elective-I	3-0-0-6	CS

CS4XX	Elective-II	3-0-0-6	CS

CS497	Capstone Project-II	0-0-3-3	CS

The objective of this project would be to encourage and provide support to students for some innovative work. The work may focus on inventing a practical solution for a AI/DS or multidisciplinary problems. Depending on the nature of the work, it may be carried out in a group or individual mode.

Semester VIII

CS457	Big data Security	2-0-2-6	CS

Data Security Overview, Basic Cryptography, symmetric key Encryption, Asymmetric key encryption, Hash function, User Authentication and Access Control, Database access control, Access control for Distributed system Cryptography for Big data Security, Homomorphic Encryption, Secure multiparty computation, Secure data access for big data Service, Integrating with cloud computing Security, Provable Data possession, Symmetric Secure Searchable Encryption, Asymmetric Secure Searchable Encryption, Privacy of out sourced data storage, Integrity of outsourced data storage and processing.

Text Books:

Database and Applications Security: Integrating Information Security and Data Management

Referred Journal/ Conference publication

XX4XX	Elective III	3-0-0-6	- -

CS4XX	Elective IV	3-0-0-6	-

CS482	individual Project	3-0-0/6-6	-

The students who work on a project are expected to work towards the goals and milestones set in AI&DS. At the end there would be demonstration of the solution and possible future work on the same problem. A dissertation outlining the entire problem, including a literature survey and the various results obtained along with their solutions is expected to be produced

Proposed Electives

Database & Data Mining
Introduction to Computational Topology
Geometric and Topological Modelling for Scientists and Engineers
Mobile Robotics
Cloud Computing
Statistical signal processing
Estimation and Detection
information theory and coding
Introduction to Network Science
Cryptography
High Performance Computing
Social Text Mining,
AI in Healthcare
Conversational AI
Discrete Differential Geometry
Computational Geometry
Topological Data Analysis
Planning Algorithms,
A Mathematical Introduction to Robotics
Advanced Signal Processing for AI and DS
Edge AI
Statistical signal processing,
Estimation and Detection,
Applications of artificial intelligence in Chemistry
Graph Representation Learning,
Advanced Network Science,

Distributed Machine Learning Deep Learning for NLP Conversational Artificial Intelligence, Machine Translation, Information Retrieval and Mining, Sentiment and Emotion Analysis Advanced Operating Systems Signal Processing and Machine Learning for Data Science Applied Time Series Analysis Probability and Random Process Applied Time Series Analysis