B. Tech. in Computer Science and Engineering Artificial Intelligence and Machine Learning (AI&ML)

National Institute of Electronics and Information Technology

An Autonomous Scientific Society under the administrative control of

Ministry of Electronics & Information Technology (MeitY),
Government of India (GoI)

NIELIT Chandigarh

Permanent Campus : Birla Farms, Bada Phull, Ropar

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Contents

Semester wise Structure and Curriculum

for

B.Tech. in Computer Science and Engineering
Artificial Intelligence and Machine Learning (AI&ML)

Semester I						
3-Week Orientation Programme						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	HS101	Communication Skills	2	0	2	3
2.	BS102	Mathematics-I	3	1	0	4
3.	BS101	Engineering Physics	2	0	2	3
4.	ES103	Mathematical Concepts for AI	3	1	0	4
5.	BS202	Engineering Chemistry	2	0	2	3
6.	ES101	Problem Solving and Programming	3	0	2	4
Total Credits : 23						

Semester II						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	BS201	Mathematics-II	3	1	0	4
2.	PC202	Object Oriented Programming	3	0	2	4
3.	PC203	Data Structures	3	0	2	4
4.	PC204	Discrete Mathematical Structures	3	1	0	4
5.	PC205	Modern Computer Architecture	3	0	0	3
6.	HS102	Design Thinking	0	0	2	1
7.	HSMC(H-102)	Universal Human Values-II: Understanding Harmony And Ethical Human Conduct	2	1	0	3
Total Credits : 23						

Semester III						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PC301	Algorithm Analysis and Design	3	0	2	4
2.	PC302	Database Systems	3	0	2	4
3.	PC303	Computer Networks	3	0	2	4
4.	PC304	Introduction to Machine Learning	3	0	2	4
5.	PC305	Artificial Intelligence	3	1	0	4
6.	OE301	Open Elective-I	3	0	0	3
7.	BS306	Mathematics-III: Introduction to Numerical Analysis	2	0	0	2
Total Credits: 23						
Any one course from following options can be opted under "Open Elective-I' (Refer, Appendix –I) 1. Internet of Thing (IoT) -(OE001) 2. Robotics- (OE002)						

Semester IV						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PC401	Theory of Computation	3	1	0	4
2.	PC402	Software Engineering	3	0	2	4
3.	PC403	Deep Learning	3	0	2	4
4.	PC404	Operating System	3	0	1	4
5.	HS401	Theory of computation Ecosystems	3	0	0	3
6.	EEC401	Minor Project	3	0	0	3
7.	AU202^	Environmental Science	3	0	0	0
Total Credits : 22						

Note: ^ Represents "Audit Course"

Semester V						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PC501	Data and Visual analytics in AI	3	0	2	4
2.	PC503	Natural Language Processing	3	0	2	4
3.	PC504	Advanced Machine Learning	3	0	2	4
4.	PC502	Optimization Techniques in Machine Leaning	3	1	0	4
5.	EEC501	Minor Project	--	--	--	3
6.	AU301^	Indian Constitution	3	0	0	0
Total Credits : 19						

Semester VI						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	EEC601	Industry / Research Lab Internship	--	--	--	16
Internship option			**Alternate option**			
• Within India or Abroad (MITACS/DAAD/ Any other aligned with GOI schemes) • To enhance hands-on skills (As per NEP-2020) • Refer Appendix-IV for some suggested Internships.			• Alternatively, Courses can also be offered from Open • Electives/Professional Electives • Two Course of 3 credits each and one Major project for 10 credits. • Students may opt for a virtual internship along with courses.			

Semester VII						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PC701	Soft Computing	3	0	2	4
2.	PE701	Professional Elective-I	3	0	2	4
3.	PE702	Professional Elective-II	3	0	2	4
4.	OE701	Open Elective-II	3	0	0	3
5.	EEC701	Capstone Project (Part-I)	----	----	----	6
Total						21
Any one course from following options can be opted under "Open Elective-II' (Refer, Appendix –I) 1. Machine Learning with Python-(OE003) 2. AI for Everyone- (OE004)						

Semester VIII						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**
1.	PE801	Professional Elective-III	3	0	2	4
2.	PE802	Professional Elective-IV	3	0	2	4
3.	EEC801	Capstone Project (Part-II)	-	-	-	10
Total						18

- ***Main emphasis should be on Project Based Learning / Experiential Learning.***
- ***There should be an option to delay internship semester to $7^{th}/8^{th}$ Semester as per institute convenience and availability of internship slots for different group of students.***

Detailed Curriculum

SEMESTER – I

HS101	Communication Skills	2L:0T:2P	3 Credits

Course Objective:

The main aim of the course is to build competence in English grammar and vocabulary and to enhance effective communication by developing Reading, Writing, Listening and Speaking skills of students. Furthermore to develop the level of competence in English required for independent and effective communication for academic and social needs.

Detailed contents:

Module 1: Fundamentals of Communication Skills

Scope and Significance of Communication Skills, Listening, Speaking, Reading and Writing, Technical Communication, Tools of Effective Communication.

Module 2: Writing Skills

Basics of Grammar – Placing of Subject and Verb, Parts of Speech, Uses of Tenses, Active Passive, Narration.

Module 3: Vocabulary Building and Writing

Word Formation & Synonyms, Antonyms, Words Often Confused, One-Word Substitutes, Idioms and Phrasal Verbs, Abbreviations of Scientific and Technical Words.

Module 4: Speaking and Technical Writing Skills

Introduction to Phonetic Sounds & Articulation, Word Accent, Interpersonal Communication, Body Language and Voice Modulation (Para linguistics and Non- Verbal), Negotiation and Persuasion, Group Discussion, Interview Techniques (Telephonic and Video Conferencing).

Writing Skills : Job Application, CV Writing, Business Letters, Report Writing & Structure, E-mail Etiquette, Blog Writing.

Module 5: Engineering Ethics

What is profession? Engineering and Professionalism, Ethics , Morality ,Types of Ethics and Morality ,Engineering Ethics, Responsibility in Engineering, Engineering Standards, The Standard Care, The Positive face and the Negative Face of Engineering Ethics

Laboratory/ Practicals:

1. Introducing Oneself, Exercise on Parts of Speech & Exercise on Tense.

2. Exercise on Agreement, Narration, Active Passive Voice & Dialogue Conversation.
3. Exercise on Writing Skills and Listening Comprehension (Audio CD).
4. Organize group discussion sessions on engineering-related topics to improve students' ability to express their ideas articulately and persuasively.
5. Assign students to prepare and deliver technical presentations on engineering topics relevant to their specialization.
6. Conduct mock job interviews to help students develop effective communication skills for professional settings.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Communication Skills - Video course	Dr. T. Ravichandran	IIT Kanpur
2.	Communication Skills	Dr. Zuchamo Yanthan	Indira Gandhi National Open University

Text Books/Suggested References:

1. The Essence of Effective Communication", Ludlow R. and Panton F., Pubs: Prentice Hall, 1992
2. "Effective Communication Skills", Kulbhushan Kumar, Khanna Publishing House, 2019.
3. "A University Grammar of English", Quirk R. and Sidney G., 3rd Edition, Pubs: Pearson Education, 2008
4. "High School English Grammar", Wren and Martin, Pubs: S. Chand & Company Ltd, 2007
5. "Essentials of Business Communication", Guffrey M.E., 8th Edition, Pubs: South-Western College Publishing, 2009
6. "Technical Communication: Principles and Practice", Raman M. and Sharma S., 2nd Edition, Pubs: Oxford University Press, 2012
7. "Effective Business Communication", Rodrigues M.V., Pubs: Concept Publishing Company, Delhi, 2003
8. "English Vocabulary in Use", McCarthy M. and Felicity O' Dell, 2nd Edition, Pubs:2010
9. Mike Martin and Roland Schinzinger, "Ethics in Engineering" McGraw Hill

Course outcomes: After completion of course, students would be able to:

1. Understand various technical writing skills
2. Apply the technical writing and communication skills in their academic and professional life.
3. Gain self-confidence with improved command over English.
4. Understand the technical aspects of communication for better performance in extra-curricular activities, recruitment process and prospective jobs.
5. Students will be perform better in the Job Interviews

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BS102	Mathematics I	3L:1T:0P	4 Credits

Course Objective:

To make the students well versed with the concepts of linear algebra. The students should also be able to solve calculus and vector calculus-based problems.

Detailed Contents:

Module 1: Linear Algebra

Vector spaces, Subspaces, basis and dimension, linear transformations, representation of transformations by Matrices, linear functionals, transpose of linear transformations, canonical forms. Linear functionals and adjoints, Bilinear forms, symmetric bilinear forms, skew symmetric bilinear forms

Module 2: Calculus

Continuity and differentiability of a function of single variable, statement of Rolle's Theorem, Lagrange's mean value theorem and applications. Double and Triple Integrals: Calculations, Areas, Volumes, change of variables

Module 3: Vector Calculus

Applications. Integrals of Vector Functions: Line integrals, Green's formula, path independence, Surface integral: definition, evaluation, Stoke's formula, Gauss-Ostrogradsky divergence theorem.

Module 4: Differential Equations

Ordinary Differential Equations: First order linear equations, Bernoulli's equations, Exact equations and integrating factor, Second order and Higher order linear differential equations with constant coefficients

Module 5: Multivariate Calculus

Integral Calculus: Definite Integrals as a limit of sums, Applications of integration to area, volume, surface area, Improper integrals. Functions of several variables: Continuity and differentiability, mixed partial derivatives, local maxima and minima for function of two variables, Lagrange multipliers.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Basic calculus for Engineers, Scientists and Economists	Prof. Joydeep Dutta	IIT Kanpur

Text Books/Suggested References:

1. G. B. Thomas, R. L. Finney. Calculus and Analytic Geometry, Ninth Edition, Pearson Education, 2010
2. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing Co., Delhi.
3. B. V. Ramana. Higher Engineering Mathematics, Tata McGraw Hill, 2017
4. E. Kreyszig. Advanced Engineering Mathematics, Wiley, 2015
5. Calculus and Analytic Geometry, G. B. Thomas and R. L. Finney, Pearson Education, 2010

Course Outcomes: After completion of course, students would be able to:

1. Understand basic algebra
2. Understand and apply calculus
3. Understand and apply vector calculus
4. Understand and apply differential equations
5. Understand and apply multivariate calculus

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BS101	Physics	3L:0T:2P	4 Credits

Course Objective:

- To equip the students with an understanding of the "Scientific Methods" so that they can use the training beneficially in their higher pursuits.
- This course gives a balance account of the fundamentals of Physics as well as some of recent developments in this area best suited to the Engineering applications in different branches.

Course Outcomes:

- The student will be able to understand many modern devices andtechnologies based on lasers and optical fibres.
- Student can also appreciate various material properties which are usedin engineering applications and devices.
- Master fundamental principles of physics applicable to engineering.
- Apply physics concepts to solve complex engineering problems.
- Develop proficiency in experimental techniques and data analysis.
- Integrate physics knowledge across engineering disciplines for problem-solving.

Enhance communication and teamwork skills for effective collaboration in engineering projects.

Detailed Contents:

Module 1: Interference and Diffraction:
Interference in thin film of uniform thickness and non-uniform thickness, Newton's rings, Michel son's interferometer, Fabry-Perot interferometer. Fresnel and Fraunhofer diffraction, Fraunhofer diffraction at circular aperture, plane diffraction grating, determination of wavelength using plane diffraction grating, dispersive power of grating, resolving power of grating.
Module 2: Electrostatics:
Gauss's law and its applications, Divergence and Curl of Electrostatic fields, Electrostatic Potential, Boundary conditions, Work and Energy, Conductors, Capacitors, Laplace's equation, Method of images, Boundary value problems in Cartesian Coordinate Systems, Dielectrics, Polarization, Bound Charges, Electric displacement, Boundary conditions in dielectrics, Energy in dielectrics, Forces on dielectrics.
Module 3: Magnetostatics
Lorentz force, Biot-Savart and Ampere's laws and their applications, Divergence and Curl of Magneto static fields, Magnetic vector Potential, Force and torque on a magnetic dipole,
Module 4: Dielectrics materials:
Magnetic materials, Magnetization, Bound currents, Boundary conditions. Diamagnetic materials, Paramagnetic materials, Ferromagnetic materials, origin of magnetization, Types of magnetic materials-hard materials and soft materials. Dielectrics-Introduction, dielectric constant, polarization, induced dipoles, permanent dipoles,polar and non-polar dielectrics, polarization-an atomic view, types of polarization.
Module 5: Classical Mechanics
Review of Newtoninan Mechanics in rectilinear coordinate system, motion in plane polar coordinates. Conservation Principles. Collision problems and centre of mass frame. Rotation about fixed axis. Non-inertial frames and pseudo forces, rigid bossy systems.
Module 6: Quantum Mechanics/ Physics:

Two−slit experiment. Dual nature of light; Compton Effect; De-Broglie hypothesis; Davisson-Germer Experiment; Phase and group velocities; Uncertainty principle; Wave-function; Schrodinger wave equation; Particle in a finite and infinite potential well; Tunnel effect. Superposition Principle, Continuity Equation for probability density; Normalization . Expectation values .Eigen values and eigen functions Stationary states, Bound states, Applications in one dimension: Particle in a box, 1-D Finite Potential well, Harmonic oscillator.

Laboratory/ Practicals (if any):

1) Determination of radius of curvature of Plano- convex lens by Newton's ring
2) Determination of wavelength by diffraction grating.
3) Study of CRO (amplitude, frequency, phase measurement).
4) Experiments on electromagnetic induction and electromagnetic braking;
5) LC circuit and LCR circuit;
6) Resonance phenomena in LCR circuits;
7) Magnetic field from Helmholtz coil;
8) Measurement of Lorentz force in a vacuum tube.
9) To study different types of Optical fibres.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Classical Physical	Prof. V. Balakrishnan	IIT Madras
2.	Modern Optics	Prof. Partha Roy Chaudhuri	IIT Kharagpur

Text Books/Suggested References:

1. Fiber optic Communication-D.C.Agarwal. Wheeler Publication, New Delhi
2. Solid state electronic devices-Streetman, Prentice Hall India, New Delhi
3. Electronic devices and circuits-Allen Mottershade, Prentice Hall India, New Delhi
4. Fiber optic communication-Keiser. Mc Graw Hill Publication
5. A course in Electrical Engineering Materials – S.P.Seth,P.V.Gupta, Dhanpat RaiPublication,New Delhi.
6. Engineering physics-Gaur and Gupta, S.Chand Publication
7. Engineering physics-Avadhanalu and Kshirsagar, S.Chand Publication

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ES102	Mathematical Concepts for AI	3L:1T:0P	4 Credits

Course Objective:
This course should help the students understand the basic mathematical background of AI. Also, the students should be able to apply statistics and probability to analyse various datasets.

Detailed contents:

Module 1: Equations, Functions and Graphs
Introduction to linear equations, Intercepts and slopes, System of equations, Exponentials, radicals and logarithms, Polynomials, Polynomial operations, Factorizations, Introduction to quadratic equations, Functions

Module 2: Derivatives and Optimizations
Rate of change, Introduction to limits, Continuity, finding limits, Differentiability, Derivative rules and operations, using derivatives to analyse functions, Second order derivatives, Optimization functions, Multivariate differentiation

Module 3: Vectors and Matrices
Introduction to vectors, Vector addition, vector multiplication, Introduction to matrices, matric multiplication, properties of matrices, types of matrices, Matrix division, solving system of equations with matrices, Matrix transformations, Eigen values and eigen vectors, rank of matrix

Module 4: Probability
Basic rules and axioms events, sample space, dependent and independent events, conditional probability, Random variables- continuous and discrete, expectation, variance, distributions- joint and conditional, Bayes' Theorem, Popular distributions- binomial, Bernoulli, poisson, exponential, Gaussian

Module 5: Statistics
Fundamentals of Data: Collection, Summarization, and Visualization; Sampling and Sampling Distributions, Central Limit Theorem; Methods of Estimation, Unbiased estimators; Confidence Interval Estimation: Z-interval, t-interval; Hypothesis Testing, Types of Errors, Rejection Region Approach and p-value Approach.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Essential Mathematics for Machine Learning	Prof. Sanjeev Kumar Prof. S. K. Gupta	IIT Roorkee

Text Books/Suggested References:

1. Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press., 2020

2. Advanced Engineering Mathematics, Reena Garg, Khanna Book Publishing Co., Delhi.
3. Machine Learning, Rajiv Chopra, Khanna Book Publishing Co., Delhi.
4. Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares, Stephen Boyd, Lieven Vandenberghe, Cambridge University Press., 2018
5. Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, Pearson Education, 2012
6. Advanced Engineering Mathematics, Wylie and Barrett, McGraw Hill, 1995
7. https://www.udemy.com/course/mathematical-foundation-for-machine-learning-and-ai/

Course outcomes: After completion of course, students would be able to:

1. To understand the mathematical background of AI.
2. Use statistical methods to analyze and collect data.
3. Use probability and statistics to analyze data
4. Use and apply hypothesis testing on different datasets

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BS202	Chemistry	3L:0T:2P	4 Credits

Course Objective:

- To present sound knowledge of chemistry fundamentals, enriching students tounderstand the role of Applied Chemistry in the field of science and engineering. To inculcate habit of scientific reasoning to do the task rationally.
- To introduce the students to basic principles of electrochemistry, cell construction and evaluation, electrochemical power sources, the importance of corrosion in metal/alloy and polymer.

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Course Content:

Module 1: Atomic and Molecular Structure
Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicentre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.
Module 2: Electrochemistry
Conductivity of electrolytes- Specific, molar and equivalent conductivity, Nernst equation for electrode potential, EMF series, hydrogen electrode, calomel electrode, glass electrode, Electrolytic and galvanic cells, cell EMF, its measurement and applications, Weston standard cell, reversible and irreversible cells, concentration cell, electrode (hydrogen gas electrode) and electrolyte concentration cell, concentration cell with and without transference.
Module 3: Intermolecular forces and potential energy surfaces
Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H3, H2F and HCN and trajectories on these surfaces.
Module 4: Periodic Properties
Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.
Module 5: Solid State
Types of solids - close packing of atoms and ions - bcc , fcc structures of rock salt - cesium chloride- spinel -normal and inverse spinel's, Stoichiometric Defect, controlled valency & Chalcogen semiconductors, Non-elemental semiconducting Materials, Preparation of Semiconductors-steps followed during the preparation of highly pure materials and further treatments. Semiconductor Devices-p-n junction diode.
Module 6: Polymer
Nomenclature, functionality, classification, methods of polymerization, mechanism of polymerization,molecular weight determination-Viscometry, light scattering methods. Plastics-Moulding constituents of a plastics and moulding of plastics into articles. Important thermoplastics and thermosetting resins- synthesis & applications of PVA, FLUON, PC, Kevlar, ABS polymer, phenolic & amino resins, epoxy resins and polyurethanes. Conductive polymers.

LABORATORY

Choice of 10-12 experiments from the following:

1. Determination of surface tension and viscosity.
2. Thin layer chromatography.
3. Ion exchange column for removal of hardness of water.
4. Determination of chloride content of water.
5. Colligative properties using freezing point depression.
6. Determination of the rate constant of a reaction.
7. Determination of cell constant and conductance of solutions.
8. Potentiometry - determination of redox potentials and emfs.
9. Synthesis of a polymer/drug.
10. Saponification/acid value of an oil.
11. Chemical analysis of a salt.
12. Lattice structures and packing of spheres.
13. Models of potential energy surfaces.
14. Chemical oscillations- Iodine clock reaction.
15. Determination of the partition coefficient of a substance between two immiscible liquids.
16. Adsorption of acetic acid by charcoal.
17. Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg.

Text/Reference Books:

1. P. C. Jain and M. Jain, Engineering Chemistry, Dhanpat Rai Publishing Company, New Delhi, 2005.
2. B.R. Puri, L.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing Company, 2008.
3. J. D. Lee, Concise Inorganic Chemistry, 5th Edn., Chapman and Hall, London, 1996.
4. S. S. Dara, S. S. Umare, A Text Book of Engineering Chemistry, S. Chand Publishing, 2011.
5. F.W. Billmayer. Textbook of Polymer Science, 3rd Edn, Wiley. N.Y. 1991.
6. A.R. West, Basic Solid State Chemistry, 2nd edition, John Wiley and Sons, 1999.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	CHEMISTRY - I	PROF. MANGALA SUNDER KRISHNAN	IITM

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

S. No.	Experiment Name	Experiment Link(s)
1	Determination of surface tension and viscosity.	http://pcv-au.vlabs.ac.in/physicalchemistry/Determination_of_Viscosity_of_Organic_Solvents/

2	Ion exchange column for removal of hardness of water.	http://icv-au.vlabs.ac.in/inorganicchemistry/Water_Analysis_Determination_of_Chemical_Parameters/
3	Determination of chloride content of water.	http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determinationof-chloride-nitk/simulation.html
4	Colligative properties using freezing point depression.	http://pcv-au.vlabs.ac.in/physicalchemistry/Cryoscopy/
5	Determination of the rate constant of a reaction.	http://pcv-au.vlabs.ac.in/physicalchemistry/EMF_Measurement/
6	Determination of cell constant and conductance of solutions.	http://icv-au.vlabs.ac.in/inorganicchemistry/Water_Analysis_Determination_of_Physical_Parameters/
7	Potentiometry - determination of redox potentials and emfs.	http://pcv-au.vlabs.ac.in/physicalchemistry/EMF_Measurement/
8	Saponification/acid value of an oil.	http://biotech01.vlabs.ac.in/biochemistry/Estimation_of_Saponification_Value_of_Fats_or_Oils/
9	Lattice structures and packing of spheres.	https://vlab.amrita.edu/?sub=1&brch=2 82&sim=370&cnt=1

Course Outcomes: The course will enable the students:

- Understand the fundamental principles of chemistry and their relevance to engineering applications.
- Apply chemical concepts to analyze and design engineering materials and processes.
- Gain knowledge of corrosion mechanisms and methods for prevention in engineering materials.
- Explore environmental chemistry and its implications for sustainable engineering practices.
- Acquire laboratory skills for conducting chemical experiments and analyzing results in engineering contexts..

Laboratory Outcomes: The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn:

- To estimate rate constants of reactions from concentration of reactants/products as a function of time.
- To measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc.
- To synthesize a small drug molecule and analyze a salt sample.

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ES101	Problem Solving and Programming	3L:0T:2P	4 Credits

Course Objective:

To develop logical skills and basic technical skills so that students should be able to solve basic computing problems. The students should be able to learn the basic of any computer programming language.

Detailed contents:

Module 1: Introduction to Programming

Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader; Application programs like editor. Algorithm, specification of algorithm. Flowcharts.

Module 2: Data Types and Operators, Variables, Sequences and Iteration

Different types of Data types, Expressions, Precedence Rules, Operators- Operators: arithmetic operators, relational operators, logical operations, bitwise operators, miscellaneous operators, Local Variables, Global Variables, List, String, Tuples, Sequence Mutations and Accumulation Patterns.

Module 3: Conditional Statements, Loops, Arrays and Strings, User Defined Data Types

If-else statement, For loop, While Loop, Nested Iteration, Concept and use of arrays, declaration and usage of arrays, 2-dimensional arrays, different types of user defined data types

Module 4: Dictionaries and Dictionary Accumulation, Functions/Methods

Dictionary Basics, Operations, Methods, Accumulation, Advantage of modularizing program into functions, function definition and function invocation. Positional Parameter Passing, Passing arrays to functions, Recursion, Library functions.

Module 5: File Handling and Memory Management

Concepts of files and basic file operations, Writing/ Reading Data to/from a .csv File, Memory Management Operations

Laboratory/ Practicals:

1. Write a program that asks the user for their name and greets them with their name.
2. Write a program that asks the user for a number n and gives them the possibility to choose between computing the sum and computing the product of 1,…,n.
3. Write a function that checks whether an element occurs in a list.
4. Write three functions that compute the sum of the numbers in a list: using a for-loop, a while-loop and recursion.
5. Given two strings, write a program that efficiently finds the longest common subsequence.

Alternative NPTEL/SWAYAM Course:

S. No.	Course Name	Instructor	Host Institute
1.	Introduction to Problem Solving and Programming - Video course	Prof. D. Gupta	IIT Kanpur
2.	Problem solving Aspects and Python Programming	Dr.S.Malliga, Dr.R.Thangarajan, Dr.S.V.Kogilavani	Kongu Engineering College

Text Books/Suggested References:

1. Programming for Problem Solving, R.S. Salaria, Khanna Book Publishing Co., Delhi.
2. Taming Python by Programming, Jeeva Jose, Khanna Book Publishing Co., Delhi.
3. Learning Python, 5th Edition, by Mark Lutz, O'Reilly Media, Inc., ISBN: 9781449355739
4. Python Crash Course: A Hands-On, Project-Based Introduction to Programming by Eric Matthes, No Starch Press.
5. Programming in Python, R.S. Salaria, Khanna Book Publishing Co., Delhi.
6. https://www.coursera.org/learn/python-basics
7. https://www.coursera.org/specializations/python-3-programming

Course outcomes: After completion of course, students would be able to:

1. Understand real world problems and developing computer solutions for those.
2. Understand the basics of python.
3. Apply python for solving basic programming solutions.
4. Create algorithms using learnt programming skills.

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SEMESTER – II

BS201	Mathematics II	3L:1T:0P	4 Credits

Course Objective:

To make the students understand the behaviour of various series. They should also be able to calculate probabilities and statistics of different datasets.

Detailed contents:

Module 1: Sequences and Series

Limit of a sequence, monotone and Cauchy sequences and properties of convergent sequences, examples. Infinite series, positive series, tests for convergence and divergence, integral test, alternating series, Leibnitz test.

Module 2: Functional Series

Pointwise and uniform convergence, basic aspects of Power series, Fourier series

Module 3: Math Foundation

Statements, Quantifiers, Operation on sets and functions, Relations, Proofs.

Module 4: Number System

Countability of algebraic numbers, Transcendental numbers and construction of Liouville's number, Equivalence classes, construction of real numbers (using Cauchy sequences), Fermat's little theorem and using it for Miller-Rabin primality test, Wilson's theorem and Primitive root theorem.

Module 5: Probability

Sample space and events, definitions of probability, properties of probability, conditional probability. Random variables: distribution functions, discrete and continuous random variables, moments of random variables, conditional expectation, Chebyshev inequality, functions of random variables. Special Distributions: Bernoulli, Binomial, Geometric, Pascal, Poisson, Exponential, Uniform, Normal distributions, Limit Theorems: Law of large numbers

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Engineering Mathematics - I	Prof. Jitendra Kumar	IIT Kharagpur

2.	Probability and Statistics	Prof. Somesh Kumar	IIT Kharagpur

Text Books/Suggested References:

1. Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, Pearson Education, 2012
2. Advanced Engineering Mathematics, Reena Garg, Khanna Book Publishing Co., Delhi
3. Advanced Engineering Mathematics, Wylie and Barrett, McGraw Hill, 1995
4. Advanced Engineering Mathematics, M.D. Greenberg, Pearson Education Asia, 2002

Course Outcomes: After completion of course, students would be able to:

1. Understand the behavior of series and their applications.
2. Understand number system and its applications.
3. Understand the concept of probability and apply in real life.
4. Understand and apply the concept of statistics.

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PC202	Object Oriented Programming	3L:0T:2P	4 Credits

Course Objective:

The students should be able to understand the concept of object-oriented programming like classes, constructors, Polymorphism, inheritance, and file handling and open source libraries.

Detailed contents:

Module 1: Introduction to Object Oriented Programming Paradigms

Introduction to various programming paradigms, advantages of OOP, comparison of OOP with Procedural Paradigm, Classes and Objects: Prototyping, Referencing the variables in functions, Inline, static and friend functions. Memory allocation for classes and objects. Arrays of objects, Constructors

Module 2: Polymorphism & Inheritance

Overriding Methods, type conversions from basic data types to user defined and vice versa, Base classes and Derived classes, types of inheritance, various types of classes, Invocation of Constructors and Destructors in Inheritance, aggregation, composition, classification hierarchies, metaclass/abstract classes, Unit Testing and Exceptions.

Module 3: Python libraries:

Basics of open-source libraries for data prepressing, modelling and visualization.

Module 4: Using Python to Access Web Data

Regular Expressions, Extracting Data, Sockets, Using the Developer Console to Explore HTTP, Retrieving Web Page, Parsing Web Pages

Module 5: Using Databases with Python

Using Databases, Single Table CRUD, Designing and Representing a Data Model, Inserting Relational Data, Reconstructing Data with JOIN, Many to Many Relationships.

Laboratory/ Practicals:

1. Write a NumPy program to compute the cross product of two given vectors
2. Write a NumPy program to calculate the QR decomposition of a given matrix 3. Write a Pandas program to convert a Panda Module Series to Python list and it's type.
4. Write a Pandas program to convert a NumPy array to a Pandas series
5. Create a Python project to get the citation from Google scholar using title and year of publication, and volume and pages of journal.
6. Create a Python project to get total Covid-19 cases, total deaths due to Covid-19, total Covid-19 patients recovered in the world.

Alternative NPTEL/SWAYAM Course:

S. No.	Course Name	Instructor	Host Institute
1.	Python For Data Science	Prof. Raghunathan Rengasamy	IIT Madras
2.	The Joy of Computing Using Python	Prof. Sudarshan Prof. Yayati Guptaiyengar	IIT Ropar, IIIT Dharwad

Text Books/Suggested References:

1. How to Think Like a Computer Scientist: Learning with Python, by Allen Downey, Jeff Elkner and Chris Meyers, SoHo Books, 2009.
2. Mastering Object-Oriented Programming, R.S. Salaria, Khanna Book Publishing Co., Delhi
3. Introduction to Computing & Problem Solving with Python, Jeeva Jose, Khanna Book Publishing, 2019.
4. https://www.coursera.org/specializations/python-3-programming#courses
5. Head First Python by Paul Barry, O′Reilly, 2010.

Course outcomes: After completion of course, students would be able to:

1. Understand the basic concepts of OOPs.
2. Apply different Python library to solve programming problems.
3. Understand the advanced concepts of python and apply for accessing databases and web data.
4. Understand APIs and third-party libraries to be used with Python.

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PC203	Data Structures	3L:0T:0P	4 Credits

Course Objective:

The students should be able to describe and implement various data structures including lists, arrays, stacks, queues, binary search trees, graphs, hash tables, and matrices. The student will be able to analyse and apply various algorithms for shortest path calculation, sorting and searching applications.

Detailed contents:

Module 1: Introduction and Elementary Data Structures

Introduction: Introduction to Data Structures and data types, Efficient use of memory, Recursion, time and space complexity of algorithms, Big O Notation and theta notations.

Elementary Data Structures: Stacks, queues, Infix, Postfix & Prefix conversions, evaluations of expressions, multiple, stacks and queues, priority queues as heaps, double ended queue, implementation of stacks and queues

Module 2: Linked Lists

Singly linked lists, linked stacks and queues, polynomial addition, sparse matrices, doubly linked lists and dynamic storage management, circular linked list, Applications of Stacks, Queues and Linked lists, Garbage collection, Josephus Problem

Module 3: Trees

Basic terminology, binary trees, binary tree traversal, representations of binary tree, application of trees, decision tree, game trees, Threaded Trees, Binary Search Tree, AVL tree, B-tree

Module 4: Graph Theory

Graph representations, Graph Traversals, Dijkstra's algorithm for shortest path, Prim's and Kruskal's Algorithm for Minimal Spanning tree

Module 5: Sorting and Searching

Searching: Linear search, binary search and hash search. Sorting: Insertion sort, selection sort, bubble sort, quick sort, merge sort, heap sort, and Bucket sort

Laboratory/ Practicals:

1. Implement infix to postfix conversion using Stack
2. Write a program for swaping nodes in a linked list without swapping data.
3. Write a program to reverse a Linked List in groups of given size.
4. Write a program for finding the first circular tour that visits all petrol pumps.
5. Implement Inorder tree traversal without recursion.
6. Write a program to Check whether a given graph is Bipartite or not.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Data Structures and Algorithms - Video course	Prof. Naveen Garg	IIT Delhi
2.	Data Structures	Dr.S.Sasikala	University of Madras

Text Books/Suggested References:

1. Data Structures, R.S. Salaria, Khanna Book Publishing, 2019.
2. Data Structures and Program Design in C By Robert L. Kruse,C.L. Tondo, Bruce Leung, Pearson Education, 2007.
3. Expert Data Structures with C/ 3rd Edition, R.B. Patel, Khanna Book Publishing, 2020.
4. Expert Data Structures with C++/ 2nd Edition, R.B. Patel, Khanna Book Publishing, 2020.
5. Data Structures Using C & C++, By Langsam, Augenstein, Tanenbaum, Pearson Education, 1989.
6. Fundamentals of Data Structures, By Ellis Horowitz and Sartaj Sahni, Computer Science Press, 2011.
7. An introduction to data structures with applications, By J.P. Trembley & P.G. Sorensen, TMH, 2004.

Course outcomes: After completion of course, students would be able to:

1. Understand the different types of data structure to be implemented using any programming language.
2. Choose the data structures that effectively model the information in a problem and analyses the efficiency trade-offs (run time and memory usage) among alternative data structure implementations or combinations.
3. Design, implement, test, and debug programs using a variety of data structures including stacks, queues, hash tables, binary and general tree structures, search trees, and graphs.
4. Apply efficient data structure (linked lists, stacks and queues) to solve a particular problem.

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PC204	Discrete Mathematical Structures	3L:1T:0P	3 Credits

Course Objective:

Students should be able to understand Discrete Mathematical Structures (DMS) for the development of theoretical computer science, problem solving in programming language using Discrete Structure and importance of discrete structures towards simulation of a problem in computer science and engineering.

Detailed contents:

Module 1: Mathematical Reasoning

Mathematical reasoning, Propositions, Negation, disjunction and conjunction, Implication and Equivalence, Truth tables, Predicates, Quantifiers, Natural deduction, Rules of Inference, Methods of proofs, Resolution principle, Application to PROLOG.

Module 2: Set Theory

Paradoxes in set theory, Inductive definition of sets and proof by induction, Peano postulates, Relations, Properties of relations, Equivalence Relations and partitions, Partial orderings, Posets, Linear and well-ordered sets.

Module 3: Combinatorics and Functions

Elementary Combinatorics, counting techniques, Recurrence relation, Generating functions, Functions; mappings, Injection and Surjections, Composition of functions, Inverse functions, Special functions, Pigeonhole principle, Recursive function theory.

Module 4: Graph Theory

Elements of graph theory, Euler graph, Hamiltonian path, trees, Tree traversals, Spanning trees, Representation of relations by graphs.

Module 5: Groups, Rings, Fields, Discrete Probability

Definition and elementary properties of groups, Semigroups, Monoids, Rings, Fields, Vector spaces and lattices, Introduction, Discrete random variables, Applications to Binary Search Tree.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Discrete Mathematical Structures - Video course	Prof. Kamala Krithivasan	IIT Madras
2.	Discrete Mathematics	Prof. Sudarshan Iyengar, Prof. Neeldhara	IIT Ropar, IIT Gandhinagar

Text Books/Suggested References:

1. K. H. Rosen, Discrete Mathematics and applications, 6th Edition, Tata McGraw Hill 2007.
2. S.B. Singh, Discrete Structures/ 3rd Edition, Khanna Book Publishing, 2019.
3. S.B. Singh, Combinatorics and Graph Theory/ 3rd Edition, Khanna Book Publishing, 2018.
4. C. L. Liu, Elements of Discrete Mathematics, 2nd Edn., Tata McGraw-Hill 2000.
5. J .L. Mott, A. Kandel, T.P .Baker, Discrete Mathematics for Computer Scientists and Mathematicians, Second edition, Prentice Hall of India 1986.
   W. K. Grassmann and J. P. Trembnlay, Logic and Discrete Mathematics, A Computer Science Perspective, Prentice Hall Inc 1996

Course outcomes: After completion of course, students would be able to:

1. Understand the basics of various discrete structures.
2. Apply applications of discrete structures in Computer Science and Engineering.

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PC205	Modern Computer Architecture	3L:1T:0P	4 Credits

Course Objective: Students should be able to understand basic principles of Computer Systems. They should be able to understand various logic design techniques and their applications. They should be capable of using high performance computing architecture.

Detailed contents:

Module 1: Basics

Designing combinational and sequential logic, computers registers and instructions, timing, and control, instructions cycle, memory reference instruction, I/O interruption, Adder and Subtractor circuits, Booth Multiplication Algorithm, Pipelining Review, control hazards and the motivation for caches, cache characteristics and basic superscalar architecture basics,

Module 2: Multi-core Architecture

Memory technologies, hierarchical memory systems, the locality principle and caching, directmapped caches, block size, cache conflicts, associative caches, write strategies, advanced optimisations, performance improvement techniques, DRAM – organisation, access techniques, scheduling algorithms and signal systems. Tiled Chip Multicore Processors (TCMP), Network on Chips (NoC), NoC router – architecture, design, routing algorithms and flow control techniques, Advanced topics in NoC and storage – compression, prefetching, QoS.

Module 3: Distributed Computing Systems and Concurrency

Relation to Parallel Multiprocessors/multicomputer Systems, Distributed and Concurrent Programs, Message Passing vs. Shared Memory Systems, Synchronous vs. Asynchronous Executions, Design Issues and Challenges, Distributed Computing Technologies, Clocks and Synchronization, Coordination and Agreement Algorithms, Global State and Distributed Transactions.

Module 4: High Performance Computing (HPC)

HPC Architecture, Parallel Processing, Parallel Memory Models, Data vs. Task Parallelism, High Throughput Computing, Vectorization, Multithreading.

Module 5: High Performance Computing with CUDA

CUDA programming model, Basic principles of CUDA programming, Concepts of threads and blocks, GPU and CPU data exchange

Alternative NPTEL/SWAYAM Course:

S. No.	Course Name	Instructor	Host Institute
1.	COMPUTER ARCHITECTURE	PROF. SMRUTI RANJAN SARANGI	IIT Delhi

2.	ADVANCED COMPUTER ARCHITECTURE	PROF.JOHN JOSE	IIT Guwahati

Text Books/Suggested References:

1. M. Morris Mano, Computer System & Architecture, Prentice Hall of India, 2002.
2. John L. Hennessy and David A Patterson, Computer Architecture-A quantitative approach, Morgan Kaufmann/ Elsevier, 4th Edition, 2007.
3. Hayes. J.P, Computer architecture and organization by McGraw-Hill Companies, 1998
4. Parallel Computer Architecture: A Hardware/Software Approach David Culler and J.P. Singh with Anoop Gupta, Morgan Kaufmann, 1998.
5. https://onlinecourses.nptel.ac.in/noc20_cs41/preview
6. https://www.coursera.org/learn/introduction-high-performance-computing#syllabus

Course outcomes: After completion of course, students would be able to:

1. Understand the organization of the Control unit, Arithmetic and Logical unit, Memory unit and the I/O unit.
2. Analyse different computer architectures and their applications.
3. Understand modern design structures of Pipelined and Multiprocessors systems.
4. Understand distributed computing architecture and high-performance computing.

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HS102	Design Thinking	0L:0T:2P	1 Credits

COURSE OBJECTIVE(S):

The objective of this Course is to provide the new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products which useful for a student in preparing for an engineering career.

COURSE CONTENTS:

Unit 1: An Insight to Learning

Understanding the Learning Process, Kolb's Learning Styles, Assessing and Interpreting

Unit 2: Remembering Memory

Understanding the Memory process, Problems in retention, Memory enhancement techniques

Unit 3: Emotions: Experience & Expression

Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers

Unit 4: Basics of Design Thinking

Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – **Empathize, Define, Ideate, Prototype, Test**

Unit 5: Being Ingenious & Fixing Problem

Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving

Unit 6: Process of Product Design

Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, **Assignment – Engineering Product Design**

Unit 7: Prototyping & Testing

What is Prototype? Why Prototype? Rapid Prototype Development process, Testing, **Sample Example**, Test Group Marketing

Unit 8: Celebrating the Difference

Understanding Individual differences & Uniqueness, Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences

Unit 9: Design Thinking & Customer Centricity

Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design

Unit 10: Feedback, Re-Design & Re-Create

Feedback loop, Focus on User Experience, Address "ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – **"Solving Practical Engineering Problem through Innovative Product Design & Creative Solution".**

Course Outcomes (CO):

Student will able to

1. Compare and classify the various learning styles and memory techniques and Apply them in their engineering education
2. Analyze emotional experience and Inspect emotional expressions to better understand users while designing innovative products
3. Develop new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products
4. Propose real-time innovative engineering product designs and Choose appropriate frameworks, strategies, techniques during prototype development
5. Perceive individual differences and its impact on everyday decisions and further Create a better customer experience

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HSMC (H-102)	Universal Human Values-II: Understanding Harmony And Ethical Human Conduct	2L:1T:0P	3 Credits

Pre-requisites: None. Universal Human Values 1 (Desirable)

1-COURSES ON HUMAN VALUES

During the Induction Program, students would get an initial exposure to human values through Universal Human Values-I. This exposure is to be augmented by this compulsory full semester foundation course.

Objectives of UHV-II Course

This introductory course input is intended:

1. To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
2. To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards valuebased living in a natural way.
3. To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature.

Thus, this course is intended to provide a much-needed orientational input in value education to the young enquiring minds.

Salient Features of the Course

The salient features of this course are:

1. It presents a universal approach to value education by developing the right understanding of reality (i.e. a worldview of the reality “as it is”) through the process of self-exploration.
2. The whole course is presented in the form of a dialogue whereby a set of proposals about various aspects of the reality are presented and the students are encouraged to self-explore the proposals by verifying them on the basis of their natural acceptance within oneself and validate experientially in living.
3. The prime focus throughout the course is toward affecting a qualitative transformation in the life of the student rather than just a transfer of information.
4. While introducing the holistic worldview and its implications, a critical appraisal of the prevailing notions is also made to enable the students discern the difference on their own right.

Course Methodology

1. The methodology of this course is explorational and thus universally adaptable. It involves a systematic and rational study of the human being vis-à-vis the rest of existence.
2. The course is in the form of 28 lectures (discussions) and 14 practice sessions.
3. It is free from any dogma or value prescriptions.
4. It is a process of self-investigation and self-exploration, and not of giving sermons. Whatever is found as truth or reality is stated as a proposal and the students are facilitated to verify it in their own right, based on their Natural Acceptance and subsequent Experiential Validation – the whole existence is the lab and every activity is a source of reflection.
5. This process of self-exploration takes the form of a dialogue between the teacher and the students to begin with, and then to continue within the student in every activity, leading to continuous self-evolution.
6. This self-exploration also enables them to critically evaluate their pre-conditionings and present beliefs.

2-COURSE TOPICS

The course has 28 lectures and 14 tutorials in 5 modules. The lectures and tutorials are of 01hour duration. Tutorial sessions are to be used to explore and practice what has been proposed during the lecture sessions.

The Teacher's Manual provides the outline for lectures as well as practice sessions. The teacher is expected to present the issues to be discussed as propositions and encourage the students to have a dialogue.

The syllabus for the lectures and practice sessions is given below:

Module 1 – Introduction to Value Education (6 lectures and 3 tutorials for practice session)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)
Lecture 2: Understanding Value Education
Tutorial 1: **Practice Session PS1** Sharing about Oneself
Lecture 3: Self-exploration as the Process for Value Education
Lecture 4: Continuous Happiness and Prosperity – the Basic Human Aspirations
Tutorial 2: Practice Session PS2 Exploring Human Consciousness
Lecture 5: Happiness and Prosperity – Current Scenario
Lecture 6: Method to Fulfill the Basic Human Aspirations
Tutorial 3: Practice Session PS3 Exploring Natural Acceptance

Expected outcome:

The students start exploring themselves: get comfortable with each other and with the teacher; they start appreciating the need and relevance for the course.

The students start finding that technical education without study of human values can generate more problems than solutions. They also start feeling that lack of understanding of human values is the root cause of most of the present-day problems; and a sustained solution

could emerge only through understanding of value-based living. Any solution brought out through fear, temptation of dogma will not be sustainable.

The students are able to see that verification on the basic of natural acceptance and experiential validation through living is the only way to verify right or wrong, and referring to any external source like text or instrument or any other person cannot enable them to verify with authenticity; it will only develop assumptions.

The students are able to see that their practice in living is not in harmony with their natural acceptance most of the time, and all they need to do is to refer to their natural acceptance to overcome this disharmony.

The students are able to see that lack of right understanding leading to lack of relationship is the major cause of problems in their family and not the lack of physical facility in most of the cases, while they have given higher priority to earning of physical facility in their life giving less value to or even ignoring relationships and not being aware that right understanding is the most important requirement for any human being.

Module 2 – Harmony in the Human Being (6 lectures and 3 tutorials for practice session)

Lecture 7: Understanding Human being as the Co-existence of the Self and the Body
Lecture 8: Distinguishing between the Needs of the Self and the Body
Tutorial 4: Practice Session PS4 Exploring the difference of Needs of Self and Body
Lecture 9: The Body as an Instrument of the Self
Lecture 10: Understanding Harmony in the Self
Tutorial 5: Practice Session PS5 Exploring Sources of Imagination in the Self
Lecture 11: Harmony of the Self with the Body
Lecture 12: Programme to ensure self-regulation and Health
Tutorial 6: Practice Session PS6 Exploring Harmony of Self with the Body

Expected outcome:

The students are able to see that they can enlist their desires and the desires are not vague. Also they are able to relate their desires to 'I' and 'Body' distinctly. If any desire appears related to both, they are able to see that the feeling is related to I while the physical facility is related to the body. They are also able to see that 'I' and Body are two realities, and most of their desires are related to 'I' and not body, while their efforts are mostly centered on the fulfilment of the needs of the body assuming that it will meet the needs of 'I' too.

The students are able to see that all physical facility they are required for a limited time in a limited quantity. Also, they are able to see that in case of feelings, they want continuity of the naturally acceptable feelings and they do not want feelings which are not naturally acceptable even for a single moment.

The students are able to see that activities like understanding, desire, though and selection are the activities of 'I' only the activities like breathing, palpitation of different parts of the body are fully the activities of the body with the acceptance of 'I' while the activities they do with their sense organs like hearing through ears, seeing through eyes, sensing through touch, tasting through tongue and smelling through nose or the activities they do with their work

organs like hands, legs etc. are such activities that require the participation of both 'I' and body.

The students become aware of their activities of 'I' and start finding their focus of attention at different moments. Also they are able to see that most of their desires are coming from outside (through preconditioning or sensation) and are not based on their natural acceptance The students are able to list down activities related to proper upkeep of the body and practice them in their daily routine. They are also able to appreciate the plants wildly growing in and around the campus which can be beneficial in curing different diseases.

Module 3 – Harmony in the Family and Society (6 lectures and 3 tutorials for practice session)

Lecture 13: Harmony in the Family – the Basic Unit of Human Interaction
Lecture 14: 'Trust' – the Foundational Value in Relationship
Tutorial 7: Practice Session PS7 Exploring the Feeling of Trust
Lecture 15: 'Respect' – as the Right Evaluation
Tutorial 8: Practice Session PS8 Exploring the Feeling of Respect
Lecture 16: Other Feelings, Justice in Human-to-Human Relationship
Lecture 17: Understanding Harmony in the Society
Lecture 18: Vision for the Universal Human Order
Tutorial 9: Practice Session PS9 Exploring Systems to fulfil Human Goal

Expected outcome:

The students are able to note that the natural acceptance (intention) is always for living in harmony, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others' intention as a result we conclude that I am a good person and other is a bad person. The students are able to see that respect is right evaluation, and only right evaluation leads to fulfilment in relationship. Many present problems in the society are an outcome of differentiation (lack of understanding of respect), like gender biasness, generation gap, caste conflicts, class struggle, dominations through power play, communal violence, clash of isms and so on so forth. All these problems can be solved by realizing that the other is like me as he has the same natural acceptance, potential and program to ensure a happy and prosperous life for them and for others through he may have different body, physical facility or beliefs. The students are able to use their creativity for education children. The students are able to see that they can play a role in providing value education for children. They are able to put in simple words the issues that are essential to understand for children and comprehensible to them. The students are able to develop an outline of holistic model for social science and compare it with the existing model.

Module 4 – Harmony in the Nature/Existence (4 lectures and 2 tutorials for practice session)

Lecture 19: Understanding Harmony in the Nature

Lecture 20: Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature

Tutorial 10: Practice Session PS10 Exploring the Four Orders of Nature

Lecture 21: Realizing Existence as Co-existence at All Levels

Lecture 22: The Holistic Perception of Harmony in Existence

Tutorial 11: Practice Session PS11 Exploring Co-existence in Existence

Expected outcome:

The students are able to differentiate between the characteristics and activities of different orders and study the mutual fulfilment among them. They are also able to see that human being s are not fulfilling to other orders today and need to take appropriate steps to ensure right participation (in terms of nurturing, protection and right utilization) in the nature.

The students feel confident that they can understand the whole existence; nothing is a mystery in this existence. They are also able to see the interconnectedness in the nature, and point out how different courses of study relate to the different units and levels. Also, they are able to make out how these courses can be made appropriate and holistic.

Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics (6 lectures and 3 tutorials for practice session)

Lecture 23: Natural Acceptance of Human Values

Lecture 24: Definitiveness of (Ethical) Human Conduct

Tutorial 12: Practice Session PS12 Exploring Ethical Human Conduct

Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order

Lecture 26: Competence in Professional Ethics

Tutorial 13: Practice Session PS13 Exploring Humanistic Models in Education

Lecture 27: Holistic Technologies, Production Systems and Management ModelsTypical Case Studies

Lecture 28: Strategies for Transition towards Value-based Life and Profession

Tutorial 14: Practice Session PS14 Exploring Steps of Transition towards Universal Human Order

Expected outcome:

The students are able to present sustainable solutions to the problems in society and nature. They are also able to see that these solutions are practicable and draw roadmaps to achieve them.

The students are able to grasp the right utilization of their knowledge in their streams of Technology/Engineering/Management/any other area of study to ensure mutual fulfilment. E.g. mutually enriching production system with rest of nature.

The students are able to sincerely evaluate the course and share with their friends. They are also able to suggest measures to make the course more effective and relevant. They are also able to make use of their understanding in the course for the happy and prosperous family and society.

Guidelines and Content for Practice Sessions (Tutorials)

In order to connect the content of the proposals with practice (living), 14 practice sessions have been designed. The full set of practice sessions is available in the Teacher's Manual as well as the website.

Practice Sessions for Module 1 – Introduction to Value Education

PS1 Sharing about Oneself
PS2 Exploring Human Consciousness
PS3 Exploring Natural Acceptance

Practice Sessions for Module 2 – Harmony in the Human Being

PS4 Exploring the difference of Needs of Self and Body
PS5 Exploring Sources of Imagination in the Self
PS6 Exploring Harmony of Self with the Body

Practice Sessions for Module 3 – Harmony in the Family and Society

PS7 Exploring the Feeling of Trust
PS8 Exploring the Feeling of Respect
PS9 Exploring Systems to fulfil Human Goal

Practice Sessions for Module 4 – Harmony in the Nature (Existence)

PS10 Exploring the Four Orders of Nature
PS11 Exploring Co-existence in Existence

Practice Sessions for Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics

PS12 Exploring Ethical Human Conduct
PS13 Exploring Humanistic Models in Education
PS14 Exploring Steps of Transition towards Universal Human Order

As an example, PS 7 is a practice session in module 3 regarding trust. It is explained below:

PS 7: Form small groups in the class and in that group initiate dialogue and ask the eight questions related to trust. The eight questions are:

1a. Do I want to make myself happy?
1b. Am I able to make myself always happy?
2a. Do I want to make the other happy?
2b. Am I able to make the other always happy?

3a. Does the other want to make him happy?	3b. Is the other able to make him always happy?
4a. Does the other want to make me happy?	4b. Is the other able to make me always happy?
Intention (Natural Acceptance)	Competence
What is the answer?	What is the answer?

Let each student answer the questions for himself/herself and everyone else. Discuss the difference between intention and competence. Observe whether you evaluate your intention and competence as well as the others' intention and competence.

Expected outcome of PS 7: The students are able to see that the first four questions are related to our Natural Acceptance i.e. intention and the next four to our Competence. They are able to note that the intention is always correct, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others' intention, as a result we conclude that I am a good person and other is a bad person.

3-READINGS:

3-1-Text Book and Teachers Manual

a. The Textbook

A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1

b. The Teacher's Manual

Teachers' Manual for A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-

3-2-Reference Books

1. JeevanVidya: EkParichaya, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj – Pandit Sunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

4-MODE OF CONDUCT (L-T-P-C 2-1-0-3)

Lecture hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.

Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and selfexploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up" ordinary" situations rather than" extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department.

Teacher preparation with a minimum exposure to at least one 8-day Faculty Development Program on Universal Human Values is deemed essential.

5-SUGGESTED ASSESSMENT:

This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:

Assessment by faculty mentor: 10 marks
Self-assessment: 10 marks
Assessment by peers: 10 marks
Socially relevant project/Group Activities/Assignments: 20 marks
Semester End Examination: 50 marks
The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

6-OUTCOME OF THE COURSE:

By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life,

and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

Therefore, the course and further follow up is expected to positively impact common graduate attributes like:

1. Holistic vision of life
2. Socially responsible behaviour
3. Environmentally responsible work
4. Ethical human conduct
5. Having Competence and Capabilities for Maintaining Health and Hygiene
6. Appreciation and aspiration for excellence (merit) and gratitude for all This is only an introductory foundational input. It would be desirable to follow it up by

a) Faculty-student or mentor-mentee programs throughout their time with the institution

b) Higher level courses on human values in every aspect of living.

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SEMESTER – III

PC301	Algorithm Analysis and Design	3L:0T:2P	4 Credits

Course Objective:

The students should be able to analyse various algorithms mainly for time and space complexity. They should be able to develop algorithm for solving various computational problems by applying various algorithm design strategies. They should be able to understand the effect of choice of data structures on the complexity of algorithm.

Detailed contents:

Module 1: Basic Concepts of Algorithms

Notion of Algorithm, Fundamentals of Algorithmic Solving, Important problem types, Fundamentals of the Analysis Framework, Asymptotic Notations and Basic Efficiency Classes, Mathematical analysis of non-recursive algorithms. Mathematical analysis of recursive algorithm: recurrence relations, solution of recurrence relations using substitution method

Module 2: Brute Force, Divide and Conquer Strategy

Selection sort, Bubble sort, Sequential searching (Linear Search), Brute force string matching, General method, Merge sort, Quick Sort, Binary Search, Strassen's matrix multiplication

Module 3: Greedy Approach and Dynamic Programming

Fractional Knapsack problem, Minimum cost spanning tree: Prim's and Kruskal's algorithm, Single source shortest path problem, Principle of optimality, Multi-stage graph problem, all pair shortest path problem, 0/1 Knapsack problem, Traveling salesperson problem

Module 4: Backtracking and Branch and Bound

General method backtracking**,** N-Queen problem, 0/1 Knapsack problem, General method of branch & bound, 0/1 Knapsack problem, Traveling sales person problem

Module 5: Lower Bound Theory and Complexity Classes

Lower bounds, Decision trees, P, NP and NP Complete problems

Laboratory/ Practicals:

1. Write a program to implement different sorting techniques.
2. Write a program to find minimum cost spanning tress.
3. Write a program to implement travelling sales person problem.
4. Write a program to find Longest Path in a Directed Acyclic Graph.
5. Write a program for Shortest path with exactly k edges in a directed and weighted graph.

6. Write a program find maximum number of edge disjoint paths between two vertices

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Design and analysis of algorithms	Prof. Madhavan Mukund	Chennai Mathematical Institute
2.	Design and analysis of algorithms	Prof. Abhiram Ranade	IIT Bombay

Text Books/Suggested References:

1. Algorithm Design, Jon Kelinberg and Eva Tardos, 1st Edition, Pearson Education 2014.
2. Design & Analysis of Algorithms, Gajendra Sharma, Khanna Book Publishing 2018.
3. Fundamentals of algorithms, Horowitz E, Sahini S, Rajasekaran S., University Press 2008.
4. Introduction to algorithms, Cormen, Leiserson, Rivest, Stein, 3rd Edition, PHI. 2012 5. An introduction to analysis of algorithms, R. Sedgewick, 1st edition, Pearson Education 1996.
6. Data Structures and Program Design in C By Robert L. Kruse, C.L. Tondo, Bruce Leung, Pearson Education. 2007.

Course outcomes: After completion of course, students would be able to:

1. Apply the best data structure for designing an algorithm to solve a given problem.
2. Evaluate different algorithms with respect to time and space complexity.
3. Create algorithms to solve various computational problems.
4. Understand different complexity classes.

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PC302	Database Systems	3L:0T:2P	4 Credits

Course objective: Students should be able to understand various basics of DBMS and query languages. They should learn different types of database systems and their applications in different scenarios.

Detailed contents:

Module 1: Introduction

Characteristics and fundamental concepts of Databases, Types of Data Models and Data Modelling, Elements of Database Systems, Classification and comparison of Database Management Systems (Regular and NoSQL Page), concurrency control, Lock based concurrency control, Time stamping methods.

Module 2: Structured and semi-structured data management

Structured data, relational databases, Relational model, Functional Dependencies, normal forms, algorithms for query optimization, Semi-structured data, document-databases, semi-structured data abstraction, representation, and search.

Module 3: Transaction Management

Transaction concept, transaction state, ACID properties, serializability, Recoverability, Implementation of Isolation, Testing for serializability.

Module 4: Unstructured Data Management

Unstructured text, Information retrieval systems, document retrieval and ranking.

Module 5: Big Data Management

Platforms for Big Data, algorithms for Map-Reduce & Hadoop, Platforms for Big Graphs, algorithms for large graphs.

Laboratory/ Practicals:

1. Implement normal forms in a database.
2. Implement basic SQL commands on a database.
3. Implement information and raking using any language.
4. Implement document retrieval and ranking using any algorithm.
5. Implement Map-reduce algorithm on any big data task.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Data Base Management System	Prof. Partha Pratim Das, Prof. Samiran Chattopadhyay	IIT Kharagpur
2.	Introduction To Database Systems	Prof. Sreenivasa Kumar	IIT Madras

Text Books/Suggested References:

1. Database System Concepts, Abraham Silberschatz, Henry F. Korth, S. Sudharshan, Tata McGraw Hill, 2006
2. Fundamentals of Database Systems, Elmsari and Navathe, Pearson Education 2013
3. Database Management Systems, Ramakrishnan and Gehrke, McGrawHill 2003
4. "An Introduction to Database Systems", C.J.Date, A.Kannan, S.Swamynathan, Pearson Education, 2006
5. Database Management Systems, R.P. Mahapatra, Khanna Book Publishing 2016.
6. J. D. Ullman, "Principles of Database Systems", 2nd Ed., Galgotia Publications
7. Learning Spark: Lightning-Fast Big Data Analysis / Holden Karau, Andy Konwinski, Patrick Wendell, Matei Zaharia / O'Reilly Media; 1st edition / ISBN-13: 978-1449358624 / ISBN-10: 1449358624
8. Data on the Web: From Relations to Semistructured Data and XML / Serge Abiteboul, Peter Buneman, Dan Suciu / 1st Edition / ISBN-13: 978-1558606227 /
9. ISBN-10: 155860622X
10. Introduction to Information Retrieval / Christopher Manning, Prabhakar Raghavan, Hinrich Schütze / book and slides available online

Course outcomes: After completion of course, students would be able to:

1. Understand the basics of databases and data management.
2. Understand various theoretical and practical principles involved in the design and use of databases systems with the help of database
3. Design and implement databases for various scenarios.
4. Design a database scenario for handling big data.

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PC303	Computer Networks	3L:0T:2P	4 Credits

Course Objective:

Students should be able to have an understanding of the fundamental concepts of computer networking and have a basic knowledge of the various network models and their uses. They should be able to analyse simple protocols and independently study literature concerning computer networks.

Detailed contents:

Module 1: Computer Networks and The Internet

What is the Internet; network edge; network core; Delay, Loss and throughput in Packet-Switched Networks; Protocol Layers and their Service Models.

Module 2: Application Layer

Principles of Network Applications; The Web and HTTP; File Transfer: FTP;Electronic Mail in the Internet; DNS - The Internet's Directory Service; Peer-to-Peer applications; Socket Programming – Creating network applications.

Module 3: Transport Layer

Introduction and Transport-Layer Services; Multiplexing and Demultiplexing; Connectionless Transport: UDP; Principles of Reliable of Data Transfer; Connection-Oriented Transport: TCP; Principles of Congestion Control, TCP Congestion Control.

Module 4: Network Layer

Introduction; Virtual circuit and datagram networks; What is inside a router; Internet Protocol (IP): Forwarding and Addressing in the Internet; Routing Algorithms; Routing in the Internet; Broadcast and Multicast Routing.

Module 5: Data Link Layer

Introduction to the link layer; Error Detection and Correction Techniques; Multiple Access links and Protocols; Switched local area networks.

Laboratory/ Practicals:

1. Write a program for using TCP and UDP Sockets.
2. Write a simulation of sliding window protocols.
3. Write a simulation of Routing Protocols.
4. Configure given network topologies using any network simulator software.
5. Write a programs for error detecting codes.
6. Write a program for Client Server Communication.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Computer Networks - Video course	Prof. Sujoy Ghosh	IIT Kharagpur
2.	Computer Networks and Internet Protocol	Prof. Soumya Kanti Ghosh, Prof. Sandip Chakraborty	IIT Kharagpur,

Text Books/Suggested References:

1. James F. Kurose and Keith W. Ross, "Computer Networking: A top-down approach", Pearson Education, 6th edition. 2012
2. A.S. Tanenbaum, "Computer Networks", 5th Edition, PHI 2010
3. Bhavneet Sidhu, "An Integrated Approach to Computer Networks", Khanna Book Publishing House 2019.
4. G. Keiser, "Local Area Networks", 2nd Edition, TMH 2002
5. D. Bertesekas and R. Gallager, "Data Networks", 2nd Edition, PHI 2000
6. William Stallings, "Data & Computer Communication", PHI, 10th Edition 2013
7. B.A. Forouzan, "Data communications and networking", TMH, 5th Edition2012
8. B.A. Forouzan, "Local Area Networks", TMH. 2002
9. B.A. Forouzan, "TCP/IP Protocol Suite", TMH.2004

Course outcomes: After completion of course, students would be able to:

1. Understand basic computer network technology.
2. Understand the different types of network topologies and protocols.
3. Analyze the different types of network devices and their functions within a network.
4. Analyze the architecture and principles of today's computer networks.
5. Understand the requirements for the future Internet and its impact on the computer network architecture.

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PC304	Introduction to Machine Learning	3L:0T:2P	4 Credits

Course Objective:
The students will understand the basics of Machine Learning. They will also learn and will be able to apply different machine learning models to various datasets.

Detailed Contents:

Module 1: Introduction
What Is Machine Learning?, How Do We Define Learning?, How Do We Evaluate Our Networks?, How Do We Learn Our Network?, What are datasets and how to handle them?, Feature sets, Dataset division: test, train and validation sets, cross validation.

Module 2: Basics of machine learning
Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning, Unsupervised Learning and Reinforcement Learning, Real life examples of Machine Learning.

Module 3: Supervised learning
Classification and Regression: K-Nearest Neighbor, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: SSE, MME, R2, confusion matrix, precision, recall, F-Score, ROC-Curve.

Module 4: Unsupervised learning
Introduction to clustering, Types of Clustering: Hierarchical, Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering.

Module 5: Miscellaneous
Dimensionality reduction techniques: PCA, LDA, ICA. Introduction to Deep Learning, Gaussian Mixture Models, Natural Language Processing, Computer Vision.

Laboratory/ Practicals:

1. Python Introduction:
2. Loops and Conditions and other preliminary stuff,
3. Functions, Classes and Modules,
4. Exceptions, Database access,
5. Mathematical computing with Python packages like: numpy, Mat- plotLib, pandas Tensor Flow, Keras
6. Implement basic ML models like SVM, KNN, K-Means, Logistic Regression, Linear Regression

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Machine Learning	Prof. Balaraman Ravindran	IIT Madras
2.	Machine Learning	Prof. Carl Gustaf Jansson	KTH, The Royal Institute of Technology

Text Books/Suggested References:

1. Introduction to Machine Learning, By Jeeva Jose, Khanna Book Publishing Co., 2020.
2. Machine Learning for Dummies, By John Paul Mueller and Luca Massaron, For Dummies, 2016.
3. Machine Learning, By Rajeev Chopra, Khanna Book Publishing Co., 2021.
4. Machine Learning: The New AI, By Ethem Alpaydin, The MIT Press, 2016.
5. Machine Learning, Tom M. Mitchell, McGraw Hill Education, 2017.
6. https://www.udacity.com/course/intro-to-machine-learning--ud120
7. https://www.coursera.org/learn/machine-learning-duke

Course Outcomes: After completion of course, students would be able to:

1. Understand basic applications and issues of Machine Learning
2. Understand the different types of datasets
3. Analyze and work with different datasets
4. Analyze various Machine Learning techniques and algorithms
5. Apply various algorithms to different datasets.

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PC305	Artificial Intelligence	3L:1T:0P	4 Credits

Course Objective:
Students will learn the basic concepts and techniques of Artificial Intelligence. They should be able to develop AI algorithms for solving practical problems.

Detailed Contents:

Module 1: Introduction
Artificial Intelligence and its applications, Artificial Intelligence Techniques, Level of models, criteria of success, Intelligent Agents, Nature of Agents, Learning Agents. AI Techniques, advantages, and limitations of AI, Impact and Examples of AI, Application domains of AI. The AI Ladder - The Journey for Adopting AI Successfully, Advice for a career in AI, Hotbeds of AI Innovation.

Module 2: Problem solving techniques
State space search, control strategies, heuristic search, problem characteristics, production system characteristics., Generate and test, Hill climbing, best first search, A* search, Constraint satisfaction problem, Mean-end analysis, Min-Max Search, Alpha-Beta Pruning, Additional refinements, Iterative Deepening.

Module 3: Logic
Propositional logic, predicate logic, Resolution, Resolution in proportional logic and predicate logic, Clause form, unification algorithm,

Module 4: Knowledge Representation schemes and reasoning
Mapping between facts and representations, Approaches to knowledge representation, procedural vs declarative knowledge, Forward vs. Backward reasoning, Matching, conflict resolution, Nonmonotonic reasoning, Default reasoning, statistical reasoning, fuzzy logic Weak and Strong filler structures, semantic nets, frame, conceptual dependency, scripts

Module 5: Planning
The Planning problem, planning with state space search, partial order planning, planning graphs, planning with propositional logic, Analysis of planning approaches, Hierarchical planning, conditional planning, Continuous and Multi Agent planning.

Tutorial List:

1. Numerical type questions on CNN-
    a. Parameters tuning
    b. Convolution function
    c. Different types of filters
2. Fuzzy Logic and Neural Networks

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	An Introduction to Artificial Intelligence	Prof. Mausam	IIT Delhi
2.	Artificial Intelligence	Prof. Sudeshna Sarkar	IIT Kharagpur

Text Books/Suggested References:

1. A Classical Approach to Artificial Intelligence, M.C. Trivedi, Khanna Book Publishing, 2019.
2. Artificial Intelligence: A modern approach by Stuart Russel, Pearson Education, 2010.
3. Artificial Intelligence by Rich and Knight, The McGraw Hill, 2017.
4. Artificial Intelligence: A new synthesis by Nils and Nilson, Elsevier, 1997.
5. Artificial Intelligence by Luger, Pearson Education, 2002.
6. Artificial Intelligence by Padhy, Oxford Press, 2005.
7. https://www.edx.org/course/artificial-intelligence-ai
8. https://www.udemy.com/course/artificial-intelligence-az/

Course outcomes: After completion of course, students would be able to:

1. Understand the basic concepts and techniques of Artificial Intelligence.
2. Apply AI algorithms for solving practical problems
3. Describe human intelligence and AI
4. Explain how intelligent system works.
5. Apply basics of Fuzzy logic and neural networks.
6. Explain Expert System and implementation

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HS306	Mathematics-III: Introduction to Numerical Analysis	0L:0T:0P	2 Credits

Course Objectives:

- To introduce basic numerical methods used in engineering and scientific problems.
- To learn techniques for solving polynomial equations.
- To enhance problem-solving and computational thinking using numerical algorithms.

Course Outcomes (COs):

By the end of the course, students will be able to:

- Understand the fundamentals of numerical approximation and errors.
- Solve systems of linear equations using direct and iterative methods.
- Apply interpolation techniques.

Module 1: Transcendental and Polynomial Equations

Transcendental function, Direct Methods Vs Iterative Methods of solution. Solution of Polynomial equations by iterative methods using initial approximation, Intermediate Value Theorem, Bisection Method. Iterative Methods for solution of polynomial equations, Secant and Regula-Falsi (chord cut) method, Newton-Raphson method.

Module 2: Interpolation and approximation

Finite Difference Operators including forward, backward and central operators. Relation between differences and derivatives. Interpolating Polynomials using finite differences, Newton Gregory formula for forward and backward interpolation. Relation between divide differences and simple differences. Interpolation for unequal intervals.

Text/Reference Books:

1. Dutta & Jana: Introductory Numerical Analysis.
2. Jain M. K., Iyengar S. R. K, Jain R. K, Numerical methods for Scientific and Engineering Computation, New Age International Publishers, New Delhi.
3. B. S. Grewal: Numerical Methods, Khanna Publishers.
4. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
5. V. Rajaraman, Computer Oriented Numerical Methods, PHI Publisher.

OE301	Open Elective - I	2L:0T:2P	3 Credits

Any one course from following options can be opted under 'Open Elective I':

1. IOT (OE001)
2. Robotics (OE002)

For syllabus, Refer Appendix - I on Open Electives.

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SEMESTER – IV

AU 2020	Environmental Science	3L:0T:0P	0 Credits

Course Objective: People working in industries or elsewhere essentially require the knowledge of environmental science so as to enable them to work and produce most efficient, economical and eco-friendly finished products.

- Solve various engineering problems applying ecosystem to produce eco – friendly products.
- Use relevant air and noise control method to solve domestic and industrial problems.
- Use relevant water and soil control method to solve domestic and industrial problems.
- To recognize relevant energy sources required for domestic and industrial applications.
- Solve local solid and e-waste problems.

Course Content:

Unit-1: Ecosystem

- Structure of ecosystem, Biotic & Abiotic components.
- Food chain and food web.
- Aquatic (Lentic and Lotic) and terrestrial ecosystem.
- Carbon, Nitrogen, Sulphur, Phosphorus cycle.
- Global warming -Causes, effects, process, Green House Effect, Ozone depletion.

Unit–2: Air and, Noise Pollution

- Definition of pollution and pollutant, Natural and manmade sources of air pollution (Refrigerants, I.C., Boiler).
- Air Pollutants: Types, Particulate Pollutants: Effects and control (Bag filter, Cyclone separator, Electrostatic Precipitator).
- Gaseous Pollution Control: Absorber, Catalytic Converter, Effects of air pollution due to Refrigerants, I.C., Boiler.
- Noise pollution: sources of pollution, measurement of pollution level, Effects of Noise pollution, Noise pollution (Regulation and Control) Rules, 2000.

Unit-3: Water and Soil Pollution

- Sources of water pollution, Types of water pollutants, Characteristics of water pollutants Turbidity, pH, total suspended solids, total solids BOD and COD: Definition, calculation.
- Waste Water Treatment: Primary methods: sedimentation, froth floatation, Secondary methods: Activated sludge treatment, Trickling filter, Bioreactor, Tertiary Method: Membrane separation technology, RO (reverse osmosis).

- Causes, Effects and Preventive measures of Soil Pollution: Causes-Excessive use of Fertilizers, Pesticides and Insecticides, Irrigation, E-Waste.

Unit– 4: Renewable sources of Energy

- Solar Energy: Basics of Solar energy. Flat plate collector (Liquid & Air). Theory of flat plate collector. Importance of coating. Advanced collector. Solar pond. Solar water heater, solar dryer. Solar stills.
- Biomass: Overview of biomass as energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilization and storage of biogas.
- Wind energy: Current status and future prospects of wind energy. Wind energy in India. Environmental benefits and problem of wind energy.
- New Energy Sources: Need of new sources. Different types new energy sources. Applications of (Hydrogen energy, Ocean energy resources, Tidal energy conversion.) Concept, origin and power plants of geothermal energy.

Unit-5: Solid Waste Management, ISO 14000 & Environmental Management

- Solid waste generation- Sources and characteristics of: Municipal solid waste, E-waste, biomedical waste.
- Metallic wastes and Non-Metallic wastes (lubricants, plastics, rubber) from industries. Collection and disposal: MSW (3R, principles, energy recovery, sanitary landfill), Hazardous waste.
- Air quality act 2004, air pollution control act 1981 and water pollution and control act1996. Structure and role of Central and state pollution control board.
- Concept of Carbon Credit, Carbon Footprint.
- Environmental management in fabrication industry.
- ISO14000: Implementation in industries, Benefits.

Text Books/References:

1. S.C. Sharma & M.P. Poonia, Environmental Studies, Khanna Publishing House, New Delhi.
2. C.N. R. Rao, Understanding Chemistry, Universities Press (India) Pvt. Ltd., 2011.
3. Arceivala, Soli Asolekar, Shyam, Waste Water Treatment for Pollution Control and
4. Reuse, Mc-Graw Hill Education India Pvt. Ltd., New York, 2007, ISBN:978-07-062099-
5. Nazaroff, William, Cohen, Lisa, Environmental Engineering Science, Willy, New York, 2000, ISBN 10: 0471144940.
6. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi
7. Rao, C. S., Environmental Pollution Control and Engineering, New Age International Publication, 2007, ISBN: 81-224-1835-X.
8. Rao, M. N.Rao, H.V.N, Air Pollution, Tata Mc-Graw Hill Publication, New delhi, 1988, ISBN: 0-07- 451871-8.
9. Frank Kreith, Jan F Kreider, Principles of Solar Engineering, McGraw-Hill, New York; 1978, ISBN: 9780070354760.
10. Aldo Vieira, Da Rosa, Fundamentals of renewable energy processes, Academic Press Oxford, UK; 2013. ISBN: 9780123978257.

11. Patvardhan, A.D, Industrial Solid Waste, Teri Press, New Delhi, 2013, ISBN:978-81-7993502-6
12. Metcalf & Eddy, Waste Water Engineering, Mc-Graw Hill, New York, 2013, ISBN: 077441206.
13. Keshav Kant, Air Pollution & Control, Khanna Publishing House, New Delhi (Edition 2018)

Open source software and website address:

1. www.eco-prayer.org
2. www.teriin.org
3. www.cpcp.nic.in
4. www.cpcp.gov.in
5. www.indiaenvironmentportal.org.in
6. www.whatis.techtarget.com
7. www.sustainabledevelopment.un.org
8. www.conserve-energy-future.com

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- 15-20% of the topics which are relatively simpler of descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations.
- Micro-projects may be given to group of students for hand-on experiences.
- Encouraging students to visit to sites such as Railway station and research establishment around the institution.

Course Outcomes: At the end of the course student will be able to

1. Understand the ecosystem and terminology and solve various engineering problems applying ecosystem knowledge to produce eco – friendly products.
2. Understand the suitable air, extent of noise pollution, and control measures and acts.
3. Understand the water and soil pollution, and control measures and acts.
4. Understand different renewable energy resources and efficient process of harvesting.
5. Understand solid Waste Management, ISO 14000 & Environmental Management.

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PC401	Theory of Computation	3L:1T:0P	4 Credits

Course Objective:

Students should be able to understand fundamental mathematical and computational principles that are foundations of computer science. They should learn about abstract models of computation, finite representations for languages and gain formal understanding of algorithms and procedures.

Detailed contents:

Module 1: Automata
Introduction to formal proof, Additional forms of proof, Inductive proofs, Finite Automata (FA), Deterministic Finite Automata (DFA), Non-deterministic Finite Automata (NFA), Finite Automata with Epsilon transitions.

Module 2: Regular Expressions and Languages
Regular Expression, FA and Regular Expressions, proving languages not to be regular, Closure properties of regular languages, Equivalence and minimization of Automata.

Module 3: Context-Free Grammars and Languages
Context-Free Grammar (CFG), Parse Trees, Ambiguity in grammars and languages, Definition of the Pushdown automata, Languages of a Pushdown Automata, Equivalence of Pushdown automata and CFG Deterministic Pushdown Automata.

Module 4: Properties of Context-Free Languages
Normal forms for CFG, Pumping Lemma for CFL, Closure Properties of CFL, Turing Machines, Programming Techniques for TM, Variations of TM, Non-Universal TM, Universal TM.

Module 5: Undecidability
A language that is not Recursively Enumerable (RE), An undecidable problem that is RE Undecidable problems about Turing Machine, Post's Correspondence Problem, The classes P and NP.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Theory of Computation - Video course	Prof. Somenath Biswas	IIT Kanpur
2.	Theory of Computation	Prof. Ragunath Tewari	IIT Kanpur

Text Books/Suggested References:

1. J.E. Hopcroft, R. Motwani and J.D. Ullman, "Introduction to Automata Theory, Languages and Computations", second Edition, Pearson Education 2007

2. H.R. Lewis and C.H. Papadimitriou, "Elements of the theory of Computation", Second Edition, Pearson Education 2003
3. R.B. Patel, "Theory of Computation (with Formal Languages)/ 2nd Edition", Khanna Book Publishing 2020.
4. Thomas A. Sudkamp," An Introduction to the Theory of Computer Science, Languages and Machines", Third Edition, Pearson Education. 2007
5. J. Martin, "Introduction to Languages and the Theory of computation" Third Edition, Tata Mc Graw Hill. 2007

Course outcomes: After completion of course, students would be able to:

1. Evaluate computer science problems as mathematical statements and to formulate proofs.
2. Understand properties of the corresponding language classes defined by various computation models and the relations between them.
3. Understand the general properties of computation and learn how to increase efficiency at which computers solve problems.
4. Understand how to model different computations problem using state machines.

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PC402	Software Engineering	3L:0T:2P	4 Credits

Course Objective:

Students should learn the concept and importance of Software Engineering. They should be able to construct software that is reasonably easy to understand, modify, maintain and reliable. They should learn strengths and weaknesses of various Software Engineering Techniques used in industrial applications.

Detailed contents:

Module 1: Introduction and Software Process Models

Software, Software Engineering, Myths, Software Process, Work Products, Importance of Software Engineering, Standard for Software Process, Waterfall Model, Prototyping Model, Iterative Enhancement Model, Spiral Model, RAD model, 4th Generation models, Formal Methods, Agile Development

Module 2: Requirement Engineering and Software Project Management

Software Requirements, Types of Requirements, Requirement Engineering Cycle, Requirements Specification document, Characteristics of Requirements, Requirement verification and validation, Role of Management in Software Development, Project Estimation Techniques, Staffing, Scheduling, Earned Value Analysis, Software Risks, Software Configuration Management, Software Process and Project metrics.

Module 3: Software Design and Coding

Process, Data and Behavioural Modelling, Design Concepts, Modularity, Architectural design, Coupling and Cohesion, Top-down and bottom-up design, Object-oriented Analysis, Functionoriented and Object-Oriented Design approach, Software Design Document, Coding styles and documentation,

Module 4: Testing and Software Quality

Testing principles, testing strategies, Black-box and White-box Testing Techniques, Levels of testing -unit, integration, system, regression, Test Plan, Test Cases Specification, Software debugging, Software Maintenance, Software Quality Assurance (SQA), SQA tasks, Software amplification and removal, Formal Technical Reviews, Software Quality Factors, ISO 9126, SEI CMM, CMMI, Software Reliability. Software Availability.

Module 5: Computer Aided Software Engineering and Advanced Topics

Computer Aided Software Engineering (CASE) and its Scope, CASE support in Software Life Cycle, Architecture of CASE Environment, Upper CASE and Lower CASE, Exposure to CASE tools. Software Process Improvement, Component Based Software Engineering, Web Engineering, Reverse Engineering, Software Engineering challenges of Big Data, Mobile Applications.

Laboratory/ Practicals:

1. Programming Exercises for software design concepts.
2. Programming Exercises for software testing concepts.
3. Programming Exercises for Project Management concepts.
4. Design and Develop UML diagrams for any Software Project.
5. Project Development with Software Engineering practices.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Software Engineering	Prof. Rajib Mall	IIT Kharagpur
2.	Software Engineering - Video course	Prof. N.L. Sarda, Prof. Rushikesh K Joshi, Prof. Umesh Bellur	IIT Bombay

Text Books/Suggested References:

1. Software Engineering-A Practitioners Approach, By R. Pressman, McGraw Hill International edition, 2004
2. Software Engineering, N.S. Gill, Khanna Publishing Co., Delhi 2018.
3. Software Engineering, Ian Sommerville, Addison-Wesley, 2010
4. An Integrated Approach to Software Engineering, Pankaj Jalote, Narosa, 2014
5. Fundamentals of Software Engineering, By Rajib Mall, PHI Learning Pvt. Ltd, 2014
6. Software Engineering (3rd ed.), By K.K Aggarwal & Yogesh Singh, New Age International Publishers, 2007

Course outcomes: After completion of course, students would be able to:

1. Understand the process of designing, creating and maintaining software.
2. Create softwares for various application domains.
3. Understand the challenges of large scale software development.
4. Understand the importance of software design and development practices.

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PC403	Deep Learning	3L:0T:2P	4 Credits

Course Objective:
To introduce the fundamentals of deep learning and the main research activities in this field. To learn architectures and optimization methods for deep neural network training

Detailed Contents:

Module 1: Introduction
History of Deep Learning, McCulloch Pitts Neuron, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Feed Forward Neural Networks, Back propagation

Module 2: Activation functions and parameters
Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Principal Component Analysis and its interpretations, Singular Value Decomposition, Parameters v/s Hyper-parameters

Module 3: Auto-encoders & Regularization
Auto encoders and relation to PCA, Regularization in auto encoders, Denoising auto encoders, Sparse auto encoders, Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Encoder Decoder Models, Attention Mechanism, Attention over images, Batch Normalization

Module 4: Deep Learning Models
Introduction to CNNs, Architecture, Convolution/pooling layers, CNN Applications, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet. Introduction to RNNs, Back propagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs

Module 5: Deep Learning Applications
Image Processing, Natural Language Processing, Speech recognition, Video Analytics

Laboratory/ Practicals (if any): Mention list of Practicals

1. Implementation of following deep learning algorithms in Python using TensorFlow:Convolution Neural Network
2. Implementation of following deep learning algorithms in Python using TensorFlow:Recurrent Neural Network
3. Project work involving application of Deep Learning

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Deep Learning	Prof. Mitesh M. Khapra	IIT Ropar

2.	Deep Learning	Prof. Prabir Kumar Biswas	IIT Kharagpur

Text Books/Suggested References:

1. Ian Goodfellow, YoshuaBengio, Aaron Courville. Deep Learning, the MIT press, 2016
2. Bengio, Yoshua. " Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1, Now Publishers, 2009
3. Deep Learning, Rajiv Chopra, Khanna Book Publishing, Delhi 2020.
4. https://nptel.ac.in/courses/106/106/106106184/
5. https://www.coursera.org/specializations/deep-learning

Course Outcomes: After completion of course, students would be able to:

1. Understand the fundamentals of deep learning and the main research activities in this field
2. Remember architectures and optimization methods for deep neural network training
3. Implement, apply and test relevant learning algorithms in TensorFlow
4. Critically evaluate the method's applicability in new contexts and construct new applications

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PC404	Operating System	3L:0T:2P	4 Credits

Objectives of the Course:

Students should be able to describe the services provided by and the design of an operating system. They should be able to understand the structure and organization of the file system, processes synchronization, process scheduling, system calls and different approaches to memory management.

Detailed contents:

Module 1: Concepts of Operating Systems

Computer system overview, concept of an operating system, batch system, multiprogramming, multiprocessing, multi user, time sharing, personal system, parallel system, real time system, simple monitors, general system architecture, System components, operating system services, system calls, system programs, system structure, Approaches to OS design and implementation: Microkernel, Layered, Kernel Approach

Module 2: Processes and Threads

Concept of process, process states, process state transitions, process control block, operations on processes, threads, concurrent processes, mutual exclusion and synchronization, principles of deadlocks, integrated deadlocks strategy, scheduling levels, scheduling criteria, Inter process synchronization, Inter process communication, Linux, IPC Mechanism, Remote procedure calls, RPC exception handling, security issues

Module 3: Memory Management and Data Management

Logical and physical address space, storage allocation and management techniques, swapping concepts of multi programming, paging, segmentation, virtual storage management strategies, demand paging, page replacement algorithm, thrashing, File organization, record blocking, access method, directory structure, protection file system structure, allocation methods, free space management, directory implementation, disk structure, disk scheduling, disk management, buffering, swap space management, RAID levels

Module 4: OS Security

Types of Threats in OS, Basic OS Security Mechanisms, Understanding the Threats: Malware Taxonomy: Viruses, Worms, Rootkits, Defence: An Overview, Logging, Auditing, and Recovery, OS-level Memory Protection

Module 5: Case Studies and OS Abstractions

Linux/Unix OS design and architecture, Unix shell, Unix operating system services, user perspective, representation of files in Unix system processes and their structure, input-output system, memory management in Unix, Processes: fork, wait, exec, exit, kill, getpid, brk, nice, sleep, trace, Files: open, close, read, write, lseek, stat, sync, Directories: mkdir, rmdir, link, unlink, mount,

umount users +, Security: chown, chmod, getuid, setuid, Inter process communication: signals, pipe, Networking: socket, accept, snd, recv, connect

Laboratory/ Practicals:

1. To perform shell programming.
2. Implement memory management techniques like paging or segmentation.
3. Implement any file allocation technique (Linked, Indexed or Contiguous).
4. Use the following system calls of UNIX operating system: mkdir, rmdir, link, unlink, mount, umount users +, chown, chmod, getuid, setuid.
5. Use the following system calls of UNIX operating system: fork, wait, exec, exit, kill, getpid, brk, nice, sleep, trace, open, close, read, write, lseek, stat, sync
6. Use the following system calls of UNIX operating system: signals, pipe, socket, accept, snd, recv, connect.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	Course Name	Instructor	Host Institute
1.	Operating System Fundamentals	Prof.Santanu Chattopadhyay	IIT Kharagpur
2.	Operating System	Prof. Sorav Bansal	IIT Delhi

Text Books/Suggested References:

1. Operating system, Galvin & Silberschatz, 7th Edition, John Willey 2004
2. Operating Systems-A Concept Based Approach, Dhamdhare, TMH 2006
3. Operating System Concepts, Ekta Walia, Khanna Book Publishing 2020.
4. Operating systems Internals and design principles By William Stallings, Pearson Education, 2012
5. Operating Systems –A Design Oriented Approach, Crowley, TMH, 2001
6. Operating systems Design and Implementation, Andrew S. Tanenbaum, Pearson Education 2009

Course outcomes: After completion of course, students would be able to:

1. Understand the basics of an operating systems and its major components.
2. Understand and implement shell programing.
3. Create and/or modify concurrent programs.
4. Apply security as well as recovery features in the design of algorithm.

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HS401	Theory of computation Ecosystems	3L:0T:0P	3 Credits

Objectives of the Course:

The students should study the development of start-up projects in the realm of globalisation, crowdsourcing and the emergence of "open-source" innovations. They should be able to search for the governmental means of support for open innovation projects, private investment resources, and assess the level of maturity of the project.

Detailed contents:

Module 1: Introduction

Introduction to Entrepreneurship Strategy: from Ideation to Exit, identifying the trade-offs, Intellectual activity & knowledge economy, sharing economy – approach to construct social-economic models, Business as construction of value creation chain in the context of open knowledge,

Module 2: Digital technologies as an open innovation's environment

Transaction costs: trust and reviewing system (personification), Hard & software - Robotics and Intelligence: Computing Recognition and Decision Making, Infrastructure Building, Cyberphysical systems as a product and as an infrastructure.

Module 3: The organization and management of open innovation projects

History the emergence of open innovation, Analysis of elements of open innovation in the traditional management, Agile – flexible project management. Methodologies within agile approach, from project to product: steps of converting ideas into goods, Stakeholders of open innovation project: customers, investors, employees etc. Indicators of effectiveness for the various groups of stakeholders.

Module 4: Start-up environment: institutions that support and finance innovative projects

Types of financing, Infrastructure supporting small innovative enterprises and start-ups, Programs to support innovative projects at the federal and regional level.

Module 5: Operational and Strategy Management

Introduction to Operations Management*:*
Operations Analysis, Coordination and Planning, Quality Management, Project Management, and Logistics and Supply Chain Management, strategy management, technological strategy.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	SWAYAM Course Name	Instructor	Host Institute
1.	Innovation and Start-up Policy	Prof. Rahul K. Mishra	IILM Institute for Higher Education

Text Books:

1. Innovation and Entrepreneurship by Peter F. Drucker (Classic Drucker Collection, 2007)
2. Joseph A. Schumpeter's views on entrepreneurship and innovation by Perihan Hazel.

Suggested References:

1. https://www.coursera.org/learn/startups-in-open-innovation.
2. https://www.coursera.org/learn/entrepreneurship-strategy.
3. https://ocw.mit.edu/courses/entrepreneurship/topic-list/

Course outcomes: After completion of course, students would be able to:

1. Understand economic models in the digital environment and types of monetisation used for open innovations.
2. Create a business model of value in the open-knowledge environment**.**

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SEMESTER – V

Course Code	:	AU301
Course Title	:	Indian Constitution
Number of Credits	:	0 (L: 3, T: 0, P: 0)
Course Category	:	AU

Course Content

Unit 1: **The Constitution - Introduction**

- The History of the Making of the Indian Constitution
- Preamble and the Basic Structure, and its interpretation
- Fundamental Rights and Duties and their interpretation
- State Policy Principles

Unit 2 – Union Government

- Structure of the Indian Union
- President – Role and Power
- Prime Minister and Council of Ministers
- Lok Sabha and Rajya Sabha

Unit 3 – State Government

- Governor – Role and Power
- Chief Minister and Council of Ministers
- State Secretariat

Unit 4 – Local Administration

- District Administration
- Municipal Corporation
- Zila Panchayat

Unit 5 – Election Commission

a. Role and Functioning
b. Chief Election Commissioner
c. State Election Commission

Suggested Learning Resources:

S. No.	Title of Book	Author	Publication
1	Ethics and Politics of the Indian Constitution	Rajeev Bhargava	Oxford University Press, New Delhi, 2008

2	The Constitution of India	B.L. Fadia	Sahitya Bhawan; New edition (2017)
3	Introduction to the Constitution of India	DD Basu	Lexis Nexis; Twenty-Third 2018 edition

Suggested Software/Learning Websites:

a. https://www.constitution.org/cons/india/const.html
b. http://www.legislative.gov.in/constitution-of-india
c. https://www.sci.gov.in/constitution
d. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/

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PC501	Data and Visual Analytics in AI	3L:0T:2P	4 Credits

Course Objective:
The student will be able to understand techniques and algorithms for creating effective visualizations based on principles from graphic design. They will also be introduced to several industry-standard software tools to create a compelling and interactive visualization of various types of data.

Detailed contents:

Module 1: Introduction
Data for Graphics, Design principles, Value for visualization, Categorical, time series, and statistical data graphics, Introduction to Visualization Tools

Module 2: Graphics Pipeline and Aesthetics and Perception
Introduction, Primitives: vertices, edges, triangles, Model transforms: translations, rotations, scaling, View transform, Perspective transform, window transform, Graphical Perception Theory, Experimentation, and the Application, Graphical Integrity, Layering and Separation, Color and Information, Using Space

Module 3: Visualization Design
Visual Display of Quantitative Information, Data-Ink Maximization, Graphical Design, Exploratory Data Analysis, Heat Map

Module 4: Multidimensional Data and Interaction
Query, Analysis and Visualization of Multi-Dimensional Relational Databases, Interactive Exploration, tSNE, Interactive Dynamics for Visual Analysis, Visual Queries, Finding Patterns in Time Series Data, Trend visualization, Animation, Dashboard, Visual Storytelling

Module 5: Collaboration
Graph Visualization and Navigation, Online Social Networks, Social Data Analysis, Collaborative Visual Analytics, Text, Map, Geospatial data

Laboratory/ Practicals:

1. Understand the meaning of big data and its application.
2. using NOSQL to get data from unstructured database.
3. explore differed open source technologies available for big data.
4. Project involving yarn, Pig, grant etc.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Data Analytics	Prof. Nandan Sudarasanam Prof. B. Ravidran	IIT Madras

2.	Deep Learning for Visual Computing	Prof. Debdoot Sheet	IIT Kharagpur

Text Books/Suggested References:

1. The Visual Display of Quantitative Information by E. Tufte, Graphics Press, 2nd Edition, 2001
2. Beginner's Guide for Data Analysis using R Programming, Jeeva Jose, Khanna Publishing 2019.
3. Data Visualization Handbook by J. Koponen, J. Hildén, CRC Press, 2019
4. The Book of Trees: Visualizing Branches of Knowledge by M. Lima, Princeton Architectural Press, 2014
5. Handbook of Graph Drawing and Visualization by R. Tamassia, CRC Press, 2013
6. Interactive Data Visualization for the Web by S. Murray O'Reilly Press, 2nd Edition, 2017

Course Outcomes: After completion of course, students would be able to:

1. Understand the key techniques and theory used in visualization, including data models, graphical perception, and techniques for visual encoding and interaction.
2. Apply knowledge to a number of common data domains and corresponding analysis tasks, including multivariate data, networks, text, and cartography.
3. Describe big data and use cases from selected business domains.
4. Explain NoSQL big data management and other technologies such as Hadoop and HDFS

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PC503	Natural Language Processing	3L:0T:2P	4 Credits

Course Objective:
The students should be able to study language and the tools that are available to efficiently study and analyze large collections of text. They should learn about and discuss the effects of electronic communication on our language.

Detailed Contents:

Module 1: Introduction
A computational framework for natural language, description of English or an Indian language in the frame work, lexicon, algorithms and data structures for implementation of the framework, Finite state automata, the different analysis levels used for NLP (morphological, syntactic, semantic, pragmatic, Recursive and augmented transition networks. Applications like machine translations.

Module 2: Word level and syntactic analysis
Word Level Analysis: Regular Expressions, Finite-State Automata, Morphological Parsing, Spelling Error Detection and correction, Words and Word classes, Part-of Speech Tagging. Syntactic Analysis: Context-free Grammar, Constituency, Parsing-Probabilistic Parsing. Machinereadable dictionaries and lexical databases, RTN, ATN.

Module 3: Semantic analysis
Semantic Analysis: Meaning Representation, Lexical Semantics, Ambiguity, Word Sense Disambiguation. Discourse Processing: cohesion, Reference Resolution, Discourse Coherence and Structure. Knowledge Representation, reasoning.

Module 4: Natural language generation
Natural Language Generation (NLG): Architecture of NLG Systems, Generation Tasks and Representations, Application of NLG. Machine Translation: Problems in Machine Translation, Characteristics of Indian Languages, Machine Translation Approaches, Translation involving Indian Languages.

Module 5: Information retrieval and lexical resources
Information Retrieval: Design features of Information Retrieval Systems, Classical, Non-classical, Alternative Models of Information Retrieval, valuation Lexical Resources: World Net, Frame Net, Stemmers, POS Tagger.

Laboratory/ Practicals:

1. Implement program to perform automatic word analysis.
2. Implement program to perform word generation.
3. Implement programs related to morphology, N-Grams, N-Grams Smoothing.
4. Implementation of Hidden Markov Models.
5. Program to build POS Tagger, Chunker.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Natural Language Processing	Prof. Pawan Goyal	IIT Kharagpur
2.	Natural Language Processing	Prof. Pushpak Bhattacharya	IIT Bombay

Text Books/Suggested References:

1. Natural Language understanding by James Allen, Pearson Education, 2002.
2. NLP: A Paninian Perspective by Akshar Bharati, Vineet Chaitanya, and Rajeev Sangal, Prentice Hall, 2016.
3. Meaning and Grammar by G. Chirchia and S. McConnell Ginet, MIT Press, 1990.
4. An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition by Daniel Jurafsky and James H. Martin, Pearson Education, 2006.
5. Natural language processing in Prolog by Gazdar, & Mellish, Addison-Wesley
6. https://www.coursera.org/specializations/natural-language-processing

Course Outcomes: After completion of course, students would be able to:

1. Understand language and the tools that are available to efficiently study and analyse large collections of text.
2. Analyze and discuss the effects of electronic communication on our language
3. Learn natural language processing with manual and automated approaches.
4. Learn computational frameworks for natural language processing.

******

PC504	Advanced Machine Learning	3L:0T:2P	4 Credits

Course Objective:
To introduce advanced concepts and methods of machine learning and to develop an understanding of the role of machine learning in massive scale automation. To design and implement various machine learning algorithms in a range of real-world applications.

Detailed Contents:

Module 1: Artificial Neural Network
Introduction to ANN, Perceptron, Cost Function, Gradient Checking, multi-layer perceptron and backpropagation algorithm that is used to help learn parameters for a neural network, Random Initialization

Module 2: Bayesian Learning
Probability theory and Bayes rule, Naive Bayes learning algorithm, Bayes nets.

Module 3: Decision Trees
Representing concepts as decision trees, Recursive induction of decision trees, best splitting attribute: entropy and information gain. Searching for simple trees and computational complexity, Overfitting, noisy data, and pruning.

Module 4: Reinforcement Learning
Reinforcement earning through feedback network, function approximation.

Module 5: Ensemble Methods
Bagging, boosting, stacking and learning with ensembles. Random Forest

Laboratory/ Practicals:

Implementation of following machine learning algorithms in various projects using Python:
1. Classification and regression algorithms.
2. K-Means Clustering.
3. Artificial Neural Network (with back-propagation).
4. Decision Trees.
5. Random Forest.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Machine Learning for Engineering and Science Applications	Dr. Balaji Srinivasan	IIT Madras

Text Books/Suggested References:

1. Tom Mitchell, Machine Learning, McGraw Hill, 1997.
2. Jeeva Jose, Introduction to Machine Learning, Khanna Book Publishing 2020.

3. Rajiv Chopra, Machine Learning, Khanna Book Publishing 2021
4. Ethem Apaydin, Introduction to Machine Learning, 2e. The MIT Press, 2010.
5. Kevin P. Murphy, Machine Learning: a Probabilistic Perspective, The MIT Press, 2012.
6. https://www.coursera.org/learn/bayesian-methods-in-machine-learning?specialization=aml
7. https://www.coursera.org/learn/practical-rl?specialization=aml

Course Outcomes: After completion of course, students would be able to:

1. Understand advanced concepts and methods of machine learning and to develop an understanding of the role of machine learning in massive scale automation.
2. Apply various machine learning algorithms in a range of real-world applications.
3. Integrate and apply their expertise to produce solutions for real-world problems.
4. Interpret and Analyze results with reasoning using different ML techniques.

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PC502	Optimization Techniques in Machine Learning	3L:1T:0P	4 Credits

Course Objective:

The students will be able to understand and analyze how to deal with changing data. They will also be able to identify and interpret potential unintended effects in your project. They will understand and define procedures to operationalize and maintain your applied machine learning model.

Detailed Contents:

Module 1: Introduction

What is optimization, Formulation of LPP, Solution of LPP: Simplex method, Basic Calculus for optimization: Limits and multivariate functions, Derivatives and linear approximations: Singlevariate functions and multivariate functions.

Module 2: Machine Learning Strategy

ML readiness, Risk mitigation, Experimental mindset, Build/buy/partner, setting up a team, Understanding and communicating change.

Module 3: Responsible Machine Learning

AI for good and all, Positive feedback loops and negative feedback loops, Metric design and observing behaviours, Secondary effects of optimization, Regulatory concerns.

Module 4: Machine Learning in production and planning

Integrating info systems, users break things, time and space complexity in production, when to retain the model? Logging ML model versioning, Knowledge transfer, Reporting performance to stakeholders.

Module 5: Care and feeding of your machine learning model

MLPL Recap, Post deployment challenges, QUAM monitoring and logging, QUAM Testing, QUAM maintenance, QUAM updating, Separating Datastack from Production, Dashboard Essentials and Metrics monitoring.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Applied Optimization for Wireless, Machine Learning and Big Data	Prof. Aditya Jagannath	IIT Kanpur

Text Books/Suggested References:

1. Jeeva Jose, Introduction to Machine Learning, Khanna Book Publishing 2020.
2. Rajiv Chopra, Machine Learning, Khanna Book Publishing 2021
3. Optimization for Machine Learning, Suvrit Sra, Sebastian Nowozin and Stephen J. Wright, MIT Press, 2011.

4. Optimization in Machine Learning and Applications, Suresh Chandra Satapathy, Anand J. Kulkarni, Springer, 2019.
5. Algorithms for Optimization by Mykel J. Kochenderfer and Tim A. Wheeler, MIT Press, 2019.
6. Accelerated Optimization for Machine Learning: First-Order Algorithms by Cong Fang, Huan Li, and Zhouchen Lin, Springer, 2020.
7. https://www.coursera.org/learn/optimize-machine-learning-model-performance

Course Outcomes: After completion of course, students would be able to:

1. Understand and analyze how to deal with changing data.
2. Understand and interpret potential unintended effects in their project.
3. Understand and define procedures to operationalize and maintain the applied machine learning model.
4. Understand how to optimize the use of Machine Learning in real-life problems.

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SEMESTER – VI

EEC601	Industry/Research Lab Internship	16 Credits

Internship can be done in an industry, Start-up, Social Internship, Work from Home Internship etc. For various available internships, student may visit **Appendix IV**.

For more guidance regarding internship, refer AICTE Internship Policy and AICTE Internship Portal (www.internship.aicte-india.org).

Or

Alternatively, courses can also be offered from Open Electives/Professional Electives. Two courses of 03 Credits each and one major project for 10 credits. Also, students may opt for a virtual internship along with course.

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SEMESTER – VII

PC701	Soft Computing	3L:0T:2P	4 Credits

Course Objective:
Students should be able to understand soft computing concepts and techniques and foster their abilities in designing and implementing soft computing-based solutions for real-world problems.

Detailed Contents:

Module 1: Introduction to neural networks
Structure and working of Biological Neural Network, Fundamentals of Artificial Neural Networks & Applications, Characteristics of Artificial Neural Networks, History of neural network research, characteristics of neural networks terminology.

Module 2: Neural networks models and Learning Methods
Models of neuron McCulloch – Pitts model, Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture, Multilayer Neural Networks, Learning Methods, Backpropagation, Counter propagation, ART, BAM, Associative memories.

Module 3: Introduction of Fuzzy logic and Neuro Fuzzy Systems
Introduction, Fuzzy sets, Fuzzy model, Fuzzy rule generation Fuzzy inference system, Defuzzification, Architecture of a Neuro-Fuzzy system and its applications.

Module 4: Machine Learning
Supervised learning: Primitive algorithms, Generative algorithms, Support Vector Machine, Ensemble methods. Unsupervised learning: K-means, Principal component analysis, Independent component analysis. Reinforcement learning and control.

Module 5: Applications
Applications of GA & GP, Hybrid systems.

Laboratory/ Practicals:

1. Setting up MATLAB.
2. Experiments with neural network toolbox.
3. Experiments with fuzzy logic toolbox.
4. Implementing fuzzy logic.
5. Implementing artificial neural network.
6. Implementing genetic algorithms.

Alternative NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Soft Computing	Prof. Debasis Samanta	IIT Kharagpur
2.	Fuzzy Logic and Neural Netwroks	Prof. Dilip Kumar Pratihar	IIT Kharagpur

Text Books/Suggested References:

1. Neuro fuzzy and soft computing by Jang, Pearson Education, 1996
2. Learning and Soft Computing by Kecman, Pearson Education, 2001
3. Fuzzy Sets and Fuzzy Logic - Klir and Yuan, PHI, 1995
4. Neural Network in computer Intelligence by Fu, TMH, 2003
5. Bio-Inspired Artificial Intelligence – Dario Floreano, PHI, 2008 6. Soft Computing – Ikvinderpal Singh, Khanna Book Publishing 2015.

Course Outcomes: After completion of course, students would be able to:

1. Understand, Identify and describe soft computing techniques and their roles in building intelligent machines.
2. Apply a soft computing methodology for a particular problem.
3. Analyze and compare solutions by various soft computing approaches for a given problem.
4. Apply genetic algorithms to combinatorial optimization problems.
5. Evaluate and compare solutions by various soft computing approaches for a given problem.

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PE701	**Professional Elective - I**	**3L:0T:2P**	**4 Credits**

Important Note: For Professional Elective Courses, A Student can opt for any one subject out of available subjects defined in **Appendix II**.

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PE702	**Professional Elective - II**	**3L:0T:2P**	**4 Credits**

Important Note: A Student can opt for any one subject out of available subjects defined in **Appendix II** on Professional Elective Courses provided he/she has not taken that particular subject in Professional Elective - I

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OE701	**Open Elective - II**	**2L:0T:2P**	**3 Credits**

Any one course from following options can be opted under 'Open Elective - II':

3. Machine Learning with Python (OE003)
4. AI for everyone (OE004)

For syllabus, Refer Appendix - I on Open Electives.

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EEC701	**Capstone Project (Part-I)**	**06 Credits**

- ***Main emphasis should be on Project Based Learning / Experiential Learning.***

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SEMESTER – VIII

PE801	**Professional Elective - III**	**3L:0T:2P**	**4 Credits**

Important Note: A Student can opt for any one subject out of available subjects defined in **Appendix II** on Professional Elective Courses provided he/she has not taken that particular subject in Professional Elective – I/II/IV

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PE802	**Professional Elective - IV**	**3L:0T:2P**	**4 Credits**

Important Note: A Student can opt for any one subject out of available subjects defined in **Appendix II** on Professional Elective Courses provided he/she has not taken that particular subject in Professional Elective – I/II/III

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EEC801	**Capstone Project (Part-II)**	**10 Credits**

- ***Main emphasis should be on Project Based Learning / Experiential Learning.***

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Internet of Things (IoT)

OE001	**Internet of Things (IOT)**	**2L:0T:2P**	**03 Credits**

Course objectives:

Understanding core technology, applications, sensors used and IOT architecture along with the industry perspective. Principles and operations of different types of sensors commonly used on mobile platform will be taught in a manner that by the end of the course the students will be able to design and implement real time solutions using IOT.

Detailed Contents:

Module 1:
Introduction to IoT: What is IoT, how does it work? Difference between Embedded device and IoT device, Properties of IoT device, IoT Ecosystem, IoT Decision Framework, IoT Solution Architecture Models, Major IoT Boards in Market

Module 2:

Setting Up Raspberry/Arduino to Create Solutions: Explore Raspberry Pi, setting up Raspberry Pi, showing working of Raspberry Pi using SSH Client and Team Viewer, Understand Sensing actions, Understand Actuators and MEMS

Module 3:

Communication Protocols used in IoT: Types of wireless communication, Major wireless Short- range communication devices, properties, comparison of these devices (Bluetooth, WIFI, ZigBee, 6LoWPAN), Major wireless Long-range communication devices, properties, comparison of these devices (Cellular IoT, LPWAN)

Module 4:

IoT Applications: Industrial Internet 4.0, Applications such as: Smart home, wearables, smart city,smart grid, connected car, connected health (digital health, telehealth, telemedicine), smart retail

Module 5:

Sensors: Applications of various sensors: Google Maps, Waze, WhatsApp, Ola Positioning sensors: encoders and accelerometers, Image sensors: cameras, Global positioning sensors: GPS, GLONASS, IRNSS, Galileo and indoor localization systems, Motion & Orientation Sensors: Accelerometer, Magnetometer, Proximity Sensor, Gyroscope Calibration, noise modeling and characterization and noise filtering and sensor data processing. Privacy &Security

Suggested References:

1. Vijay Madisetti and Arshdeep Bahga, Internet of Things (A Hands-on Approach), 1stEdition, VPT, 2014
2. Francis da Costa, Rethinking the Internet of Things: A Scalable Approach to ConnectingEverything, 1stEdition, Apress Publications, 2014
3. CunoPfister, Getting Started with the Internet of Things, O Reilly Media, 2011
4. Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, SpringerInternational Publishing, 2015

Alternative NPTEL/SWAYAM Course (if any):

NPTEL Course Name	**Instructor**	**Host Institute**
Introduction to Internet of Things	Prof. Sudip Misra	IIT Kharagpur
Introduction to Industry 4.0 and Industrial Internet of Things	Prof. Sudip Misra	IIT Kharagpur

Course Outcomes: After completion of course, students would be able to:

1. Understand core technology, applications, sensors used and IOT architecture along with theindustry perspective.
2. Understand Raspberry's working and implementation.
3. Understand various communication protocols used in IoT.
4. Apply various IOT technologies in real-life applications.

Robotics

OE002	Robotics	2L:0T:2P	03 Credits

Course Objective:

The students will be able to understand the basic concepts and fundamentals of robotics. They will also be able to use AI in the field of robotics.

Detailed Contents:

Module 1:
Introduction: Introduction to Robotics Fundamentals of Robotics, Robot Kinematics: Position Analysis, Dynamic Analysis and Forces, Robot Programming languages & systems: Introduction, the three levels of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages.

Module 2:

Need of AI in Robotics: History, state of the art, Need for AI in Robotics. Thinking and acting humanly, intelligent agents, structure of agents.

Module 3:

Game Playing: AI and game playing, plausible move generator, static evaluation move generator, game playing strategies, problems in game playing.

Module 4:

Robotics fundamentals: Robot Classification, Robot Specification, notation, kinematic representations and transformations, dynamics techniques; trajectory planning and control.

Module 5:

Robotics and Its applications: DDD concept, Intelligent robots, Robot anatomy-Definition, law ofrobotics, History and Terminology of Robotics-Accuracy and repeatability of Robotics-Simple problems-Specifications of Robot-Speed of Robot, Robot joints and links-Robot classifications-Architecture of robotic systems-Robot Drive systems-Hydraulic, Pneumatic and Electric system

Suggested References:

1. Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Peter Corke,Springer, 2011.

2. Robotics: Everything You Need to Know About Robotics from Beginner to Expert, Peter McKinnon, Createspace Independent Publishing Platform, 2016.
3. Introduction to AI Robotics, Second Edition, By Robin R. Murphy, MIT press, 2001.
4. Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks usingAI techniques, Francis X. Govers, Packt Publishers, 2018.

Alternative NPTEL/SWAYAM Course (if any):

NPTEL Course Name	**Instructor**	**Host Institute**
Introduction to Robotics	Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan	IIT Madras
Robotics	Prof. Dilip Kumar Pratihar	IIT Kharagpur

Machine Learning withPython

OE003	**Machine Learning with Python**	**2L:0T:2P**	**03 Credits**

Course Objective:

The students will be able to handle various datatypes and datasets in python. They will also be ableto implement various machine learning model sin python.

Detailed Contents:

Module 1:
Introduction to Python: Data Types, Operators, Expression, Indexing & Slicing, Strings,Conditionals, Functions, Control Flow, Nested Loops, Sets & Dictionaries

Module 2:

Introduction to Machine Learning: Machine Learning Vs Statistical Modelling, Supervised vs Unsupervised Learning, Supervised Learning Classification, Unsupervised Learning, Reinforcement Learning, Applications, Python libraries suitable for Machine Learning: Pandas, Numpy, Scikit-learn, visualization libraries: matplotlib etc.

Module 3:

Regression: Simple Linear Regression, Multiple Linear Regression, Non-linear Regression, Model Evaluation in Regression Models, Evaluation Metrics in Regression Models

Module 4:

Classification: Introduction to Classification, K-Nearest Neighbour, Decision Trees, Logistic Regression, Support Vector Machines, Logistic regression vs Linear regression, Evaluation Metricsin Classification

Module 5:

Unsupervised Learning: Intro to Clustering, K-Means Clustering, Hierarchical Clustering, Density-Based Clustering, Content-based recommender systems, Collaborative Filtering

Laboratory/ Practicals:

Implementation of following machine learning algorithms in various projects using Python:

1. Classification and regression algorithms.
2. Artificial Neural Network (with back-propagation).
3. Mathematical computing with Python packages like: numpy, Mat- plotLib, pandas TensorFlow, Keras
4. Implement basic ML models like SVM, KNN, K-Means, Logistic Regression,

LinearRegression

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Machine Learning	Prof. Balarama nRavindran	IIT Madras
2.	Machine Learning	Prof. Carl Gustaf Jansson	KTH, The Royal Instituteof Technology

Suggested References:

1. Hands–On Machine Learning with Scikit–Learn and TensorFlow 2e: Concepts, Tools, andTechniques to Build Intelligent Systems, Aurelien Geron, O'Reilly, 2017
2. Python Machine Learning - Third Edition, Sebastian Raschka , Vahid Mirjalili, PacktPublishers, 2019
3. Introduction to Machine Learning with Python: A Guide for Data Scientists 1st Editionby Andreas C. Müller, Sarah Guido, O'Reilly, 2016
4. https://www.coursera.org/learn/machine-learning-with-python
5. https://www.edx.org/course/machine-learning-with-python-a-practical-introduct

Course Outcomes: After completion of course, students would be able to:

1. Understand python and be able to handle various datasets in python.
2. Understand basic machine learning algorithms.
3. Apply different classification and clustering algorithms for problem solving.
4. Create basic machine learning algorithms in python.

AI for Everyone

OE004	**AI for Everyone**	**2L:0T:2P**	**03 Credits**

Course Objective: The students should be able to understand what is AI, its applications and use cases and how it is transforming our lives.

Detailed contents:

Module 1:

Introduction

Machine Learning, What is data, The terminology of AI, What makes an AI company, What machine learning can and cannot do, Non-technical explanation of deep learning, basics of neural networks, Examples of AI, Application domains of AI.

Module 2:

Building AI projects

Workflow of a machine learning project, Workflow of a data science project, how to use data, How to choose an AI project, Working with an AI team, How to process and visualize data, Technical tools for AI teams, use of python in AI related projects.

Module 3:

Building AI in Your Company

Case study: Smart speaker, Case study: Self-driving car, Example roles of an AI team, AI pitfalls toavoid, Survey of major AI application areas

Module 4:

AI and Society

A realistic view of AI, Discrimination / Bias, Adversarial attacks on AI, Adverse uses of AI, AI anddeveloping economies, AI and jobs

Module 5:

AI case studies related to a

specific domain.

Laboratory/ Practicals:

1. Numerical type questions on CNN-
   a. Parameters tuning
   b. Convolution function
   c. Different types of filters

2. Fuzzy Logic and Neural Networks

3. Implement self-driving vehicle algorithm.

Alternative NPTEL/SWAYAM Course (if any):

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Artificial Intelligence	Prof. Sudeshna Sarkar	IIT Kharagpur
2	An Introduction to Artificial Intelligence	Prof. Mausam	IIT Delhi

Suggested References:

1. https://www.coursera.org/learn/ai-for-everyone#syllabus
2. https://www.edx.org/course/artificial-intelligence-for-everyone
3. Artificial Intelligence: A Modern Approach, by Stuart Russell, Peter Norvig, Prentice Hall,2010
4. Artificial Intelligence: The Basics by Kevin Warwick, Routledge, 2011
5. Artificial Intelligence for Humans by Jeff Heaton, CreateSpace Independent Publishing,2015

Course outcomes: After completion of course, students would be able to:

1. Understand the basic concepts of AI and machine learning.
2. Understand the working of self-driving systems.
3. Understand how to build different AI projects.
4. Apply AI techniques to any application domain.

Course outcomes: After completion of course, students would be able to:

1. Understand the basics of robotics
2. Understand game playing concepts involving robotics and AI.
3. Apply robotics to create robot driven systems.
4. Analyze and co-relate robotics with AI and use in real-world applications