AC –
Item No. –

University of Mumbai

Bachelor of Engineering

in

- Computer Science and Engineering (Data Science)
- Computer Science and Engineering (Artificial Intelligence and Machine Learning)
- Artificial Intelligence and Data Science
- Artificial Intelligence and Machine Learning
- Data Engineering

Fourth Year with Effect from AY 2023-24

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

University of Mumbai

Sr. No.	Heading	Particulars
1	Title of the Course	**Fourth Year Engineering**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances/ Regulations(if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / **Semester** (Strike out which is not applicable)
8	Status	**New**/ ~~Revised~~ (Strike out which is not applicable)
9	To be implemented from Academic Year	**With effect from Academic Year:2023-2024**

Dr. S.K.Ukarande
Associate Dean,
Faculty of Science and Technology
University of Mumbai

Dr. Anuradha Muzumdar
Dean,
Faculty of Science and Technology
University of Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal meansof quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2021-22. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2022-23, 2023-24, respectively.

Dr. S.K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Incorporation and Implementation of Online Contents fromNPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S.K.Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preface by Board of Studies in
Computer Engineering

Dear Students and Teachers, we, the members of Board of Studies Computer Engineering, are very happy to present Fourth Year Computer Engineering Specialization in Data Science, Data Engineering, Artificial Intelligence and Machine leaning syllabus effective from the Academic Year 2021-22 (REV-2019'C' Scheme). We are sure you will find this syllabus interesting, challenging, fulfill certain needs and expectations.

Emerging Programs in the field of Computer Engineering is one of the most sought-after courses amongst engineering students. The syllabus needs revision in terms of preparing the student for the professional scenario relevant and suitable to cater the needs of industry in present day context. The syllabus focuses on providing a sound theoretical background as well as good practical exposure to students in the relevant areas. It is intended to provide a modern, industry-oriented education in Computer Engineering. It aims at producing trained professionals who can successfully acquaint with the demands of the industry worldwide. They obtain skills and experience in up-to-date the knowledge to analysis, design, implementation, validation, and documentation of computer software and systems.

The revised syllabus is finalized through a brain storming session attended by Heads of Departments or senior faculty from the Department of Computer Engineering of the affiliated Institutes of the Mumbai University. The syllabus falls in line with the objectives of affiliating University, AICTE, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements.

The salient features of the revised syllabus are:

1. Reduction in credits to 170 is implemented to ensure that students have more time for extracurricular activities, innovations, and research.
2. The department Optional Courses will provide the relevant specialization within the branch to a student.
3. Introduction of Skill Based Lab and Mini Project to showcase their talent by doing innovative projects that strengthen their profile and increases the chance of employability.
4. Students are encouraged to take up part of course through MOOCs platform SWAYAM

We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Board of Studies in Computer Engineering

Prof. Sunil Bhirud	: Chairman
Prof. SunitaPatil	: Member
Prof. Leena Ragha	: Member
Prof. Subhash Shinde	: Member
Prof .Meera Narvekar	: Member
Prof. Suprtim Biswas	: Member
Prof. Sudhir Sawarkar	: Member
Prof. Dayanand Ingle	: Member
Prof. Satish Ket	: Member

Program Structure for Fourth Year CSE (AIML), CSE (DS) AI&DS, DE, AI&ML

UNIVERSITY OF MUMBAI (With Effect from 2023-2024)

Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
CSC701	Deep Learning	3	--	3	--	3
CSC702	Big Data Analytics	3	--	3		3
CSDO 701X	Department Level Optional Course-3	3	--	3	--	3
CSDO 702X	Department Level Optional Course-4	3	--	3	--	3
ILO 701X	Institute Level Optional Course-1	3	--	3	--	3
CSL701	Deep Learning Lab	--	2	--	1	1
CSL702	Big Data Analytics Lab	--	2	--	1	1
CSDOL 701X	Department Level Optional Course-3 Lab	--	2	--	1	1
CSDOL 702X	Department Level OptionalCourse-4 Lab	--	2	--	1	1
CSP701	Major Project1	--	6#	--	3	3
Total		**15**	**14**	**15**	**7**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. & oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
CSC701	Deep Leaning	20	20	20	80	3	--	--	100
CSC702	Big Data Analytics	20	20	20	80	3	--	--	100
CSDO 701X	Department Level Optional Course-3	20	20	20	80	3	--	--	100
CSDO 702X	Department Level Optional Course-4	20	20	20	80	3	--	--	100
ILO 701X	Institute Level Optional Course-1	20	20	20	80	3	--	--	100
CSL701	Deep Leaning Lab	--	--	--	--	--	25	25	50
CSL702	Big Data Analytics Lab	--	--	--	--	--	25	25	50
CSDOL 701X	Department Level Optional Course-3 Lab						25	-	25
CSDOL 702X	Department Level OptionalCourse-4 Lab	--	--	--	--	--	25	-	25
CSP701	Major Project1	--	--	--	--	--	50	25	75
Total		**--**	**--**	**100**	**400**	**--**	**150**	**75**	**725**

Program Structure for Fourth Year CSE (AIML), CSE (DS) AI&DS, DE, AI&ML

UNIVERSITY OF MUMBAI (With Effect from 2023-2024)

Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
CSC801	Advanced Artificial Intelligence	3	--	3	--	3
CSDO 801X	Department Level Optional Course-5	3	--	3	--	3
CSDO 802X	Department Level Optional Course-6	3	--	3	--	3
ILO 801X	Institute Level Optional Course-2	3	--	3	--	3
CSL801	Advanced Artificial Intelligence Lab	--	2	--	1	1
CSDOL 801X	Department Level OptionalCourse-5 Lab	--	2	--	1	1
CSDOL 802X	Department Level OptionalCourse-6 Lab	--	2	--	1	1
CSP801	Major Project-2	--	12#	--	6	6
Total		**12**	**18**	**12**	**9**	**21**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract & oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
CSC801	Advanced Artificial Intelligence	20	20	20	80	3	--	--	100
CSDO801X	Department Level Optional Course-5	20	20	20	80	3	--	--	100
CSDO 802X	Department Level Optional Course-6	20	20	20	80	3	--	--	100
ILO80X	Institute Level Optional Course-2	20	20	20	80	3	--	--	100
CSL801	Advanced Artificial Intelligence Lab	--	--	--	--	--	25	25	50
CSDOL 801X	Department Level Optional Course -5 Lab	--	--	--	--	--	25	25	50
CSDOL 802X	Department Level Optional Course -6 Lab						25	25	50
CSP801	Major Project 2	--	--	--	--	--	100	50	150
Total		**--**	**--**	**80**	**320**	**--**	**175**	**125**	**700**

Major Project 1 and 2 :

- Students can form groups with minimum 2 (Two) and not more than 4 (Four)
- Faculty Load : In Semester VII – ½ hour per week per project group
  In Semester VIII – 1 hour per week per project group

Program Structure for Fourth Year CSE (AIML), CSE (DS) AI&DS, DE, AI&ML

UNIVERSITY OF MUMBAI (With Effect from 2023-2024)

Department and Institute Optional Courses and Labs

Semester	**Department/ Institute Optional Courses and Labs**	**Subject and Labs**
VII	Department Optional Course -3	CSDO7011: Natural Language Processing CSDO7012.: AI for Healthcare CSDO7013: Neural Network & Fuzzy System
	Department Optional Lab -3	CSDOL7011: Natural Language Processing Lab CSDOL7012.: AI for Healthcare Lab CSDOL7013: Neural Network & Fuzzy System
	Department Optional Course -4	CSDO7021: User Experience Design with VR CSDO7022: Blockchain Technologies CSDO7023: Game Theory for Data Science
	Department Optional Lab -4	CSDOL7021: User Experience Design with VR Lab CSDOL7022: Blockchain Technologies Lab CSDOL7023: Game Theory for Data Science Lab
	Institute level Optional Courses-I	ILO7011:Product Lifecycle Management ILO7012: Reliability Engineering ILO7013.: Management Information System ILO7014: Design of Experiments ILO7015: Operation Research ILO7016: Cyber Security and Laws ILO7017: Disaster Management & Mitigation Measures ILO7018: Energy Audit and Management ILO7019: Development Engineering

Program Structure for Fourth Year CSE (AIML), CSE (DS) AI&DS, DE, AI&ML

UNIVERSITY OF MUMBAI (With Effect from 2023-2024)

Department and Institute Optional Courses and Labs

Semester	**Department/ Institute Optional Courses and Labs**	**Subject and Labs**
VIII	Department Optional Course -5	CSDO8011: AI for financial & Banking application CSDO8012: Quantum Computing CSDO8013: Reinforcement Learning
	Department Optional Lab -5	CSDOL8011: AI for financial & Banking application Lab CSDOL8012: Quantum Computing Lab CSDOL8013: Reinforcement Learning Lab
	Department Optional Course -6	CSDO8021: Graph Data Science CSDO8022: Recommendation Systems CSDO8023: Social Media Analytic
	Department Optional Lab -6	CSDOL8021: Graph Data Science Lab CSDOL8022: Recommendation Systems Lab CSDOL8023: Social Media Analytic Lab
	Institute level Optional Courses-II	ILO8021: Project Management ILO8022: Finance Management ILO8023: Entrepreneurship Development and Management ILO8024: Human Resource Management ILO8025: Professional Ethics and CSR ILO8026: Research Methodology ILO8027: IPR and Patenting ILO8028: Digital Business Management ILO8029: Environmental Management

Course Code:	Course Title	Credit
CSC701	Deep Learning	3

Prerequisite: Basic mathematics and Statistical concepts, Linear algebra, Machine Learning	
Course Objectives:	
1	To learn the fundamentals of Neural Network.
2	To gain an in-depth understanding of training Deep Neural Networks.
3	To acquire knowledge of advanced concepts of Convolution Neural Networks, Autoencoders and Recurrent Neural Networks.
4	Students should be familiar with the recent trends in Deep Learning.
Course Outcomes:	
1	Gain basic knowledge of Neural Networks.
2	Acquire in depth understanding of training Deep Neural Networks.
3	Design appropriate DNN model for supervised, unsupervised and sequence learning applications.
4	Gain familiarity with recent trends and applications of Deep Learning.

Module		Content	39Hrs
1		**Fundamentals of Neural Network**	**4**
	1.1	History of Deep Learning, Deep Learning Success Stories, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks	
	1.2	Deep Networks: Three Classes of Deep Learning Basic Terminologies of Deep Learning	
2		**Training, Optimization and Regularization of Deep Neural Network**	**10**
	2.1	**Training Feedforward DNN** Multi Layered Feed Forward Neural Network, Learning Factors, Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, Leaky ReLU, Loss functions: Squared Error loss, Cross Entropy, Choosing output function and loss function	
	2.2	**Optimization** Learning with backpropagation, Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Nesterov Accelerated GD, AdaGrad, Adam, RMSProp	
	2.3	**Regularization** Overview of Overfitting, Types of biases, Bias Variance Tradeoff Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, Adding noise to input and output	
3		**Autoencoders: Unsupervised Learning**	**6**
	3.1	Introduction, Linear Autoencoder, Undercomplete Autoencoder, Overcomplete Autoencoders, Regularization in Autoencoders	

	3.2	Denoising Autoencoders, Sparse Autoencoders, Contractive Autoencoders	
	3.3	Application of Autoencoders: Image Compression	
4		**Convolutional Neural Networks (CNN): Supervised Learning**	**7**
	4.1	Convolution operation, Padding, Stride, Relation between input, outpu and filter size, CNN architecture: Convolution layer, Pooling Layer Weight Sharing in CNN, Fully Connected NN vs CNN, Variants of basic Convolution function, Multichannel convolution operation,2D convolution.	
	4.2	Modern Deep Learning Architectures: LeNET: Architecture, AlexNET: Architecture, ResNet : Architecture	
5		**Recurrent Neural Networks (RNN)**	**8**
	5.1	Sequence Learning Problem, Unfolding Computational graphs, Recurrent Neural Network, Bidirectional RNN, Backpropagation Through Time (BTT), Limitation of " vanilla RNN" Vanishing and Exploding Gradients, Truncated BTT	
	5.2	Long Short Term Memory(LSTM): Selective Read, Selective write, Selective Forget, Gated Recurrent Unit (GRU)	
6		**Recent Trends and Applications**	**4**
	6.1	Generative Adversarial Network (GAN): Architecture	
	6.2	Applications: Image Generation, DeepFake	

Textbooks:	
1	Ian Goodfellow, Yoshua Bengio, Aaron Courville. ―Deep Learning‖, MIT Press Ltd, 2016
2	Li Deng and Dong Yu, ―Deep Learning Methods and Applications‖, Publishers Inc.
3	Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill.
4	JM Zurada ―Introduction to Artificial Neural Systems‖, Jaico Publishing House
5	M. J. Kochenderfer, Tim A. Wheeler. ―Algorithms for Optimization‖, MIT Press.
References:	
1	Deep Learning from Scratch: Building with Python from First Principles- Seth Weidman by O`Reilley
2	François Chollet. ―Deep learning with Python ―(Vol. 361). 2018 New York: Manning.
3	Douwe Osinga. ―Deep Learning Cookbook‖, O'REILLY, SPD Publishers, Delhi.
4	Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc
5	S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India

Assessment:	
Internal Assessment:	
The assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All questions carry equal marks.
3	Question 1 and question 6 will have questions from all modules. Remaining 4 questions will be based on the remaining 4 modules.

4	Only four questions need to be solved.
5	In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Useful Links	
1	http://www.cse.iitm.ac.in/~miteshk/CS6910.html
2	https://nptel.ac.in/courses/106/106/106106184/
3	https://www.deeplearningbook.org/

Course Code	Course/Subject Name	Credits
CSC702	Big Data Analytics	3

Prerequisite: Some prior knowledge about Java programming, Basics of SQL, Data mining and machine learning methods would be beneficial.	
Course Objectives:	
1	To provide an overview of an exciting growing field of big data analytics.
2	To introduce programming skills to build simple solutions using big data technologies such as MapReduce and scripting for NoSQL, and the ability to write parallel algorithms for multiprocessor execution
3	To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.
4	To enable students to have skills that will help them to solve complex real-world problems in decision support.
5	To provide an indication of the current research approaches that is likely to provide a basis for tomorrow's solutions.
Course Outcomes:	
1	Understand the key issues in big data management and its associated applications for business decisions and strategy.
2	Develop problem solving and critical thinking skills in fundamental enabling techniques like Hadoop, Map reduce and NoSQL in big data analytics.
3	Collect, manage, store, query and analyze various forms of Big Data.
4	Interpret business models and scientific computing paradigms,and apply software tools for big data analytics.
5	Adapt adequate perspectives of big data analytics in various applications like recommender systems, social media applications etc.
6	Solve Complex real world problems in various applications like recommender systems, social media applications, health and medical systems, etc.

Module		Detailed Contents	Hours
1		**Introduction to Big Data & Hadoop**	**4**
	1.1 1.2 1.3 1.4 1.5 1.6	Introduction to Big Data, Big Data characteristics, types of Big Data, Traditional vs. Big Data business approach, Case Study ofBig Data Solutions. Concept of Hadoop Core Hadoop Components; Hadoop Ecosystem	
2		**Hadoop HDFS and Map Reduce**	**7**
	2.1	Distributed File Systems: Physical Organization of Compute Nodes,Large-Scale File-System Organization.	
	2.2	MapReduce: The Map Tasks,Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping With Node Failures.	
	2.3	Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce, Union, Intersection, and Difference by MapReduce .	
	2.4	Hadoop Limitations .	
3		**NoSQL**	**5**
	3.1	Introduction to NoSQL, NoSQL Business Drivers.	
	3.2	NoSQL DataArchitecture Patterns: Key-value stores, Graph stores, Column family (Bigtable)stores, Document stores, Variations of NoSQL architectural patterns, NoSQL Case Study.	
	3.3	NoSQL solution for big data, Understanding the types of big data problems; Analyzing big data with ashared-nothing architecture; Choosing distribution models: master-slaveversus peer-to-peer; NoSQL systems to handle big data problems, peer-to-peer; Four ways that NoSQL systems handle big data problems.	
4		**Mining Data Stream**	**9**
	4.1	The Stream Data Model: A Data-Stream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing.	
	4.2	Sampling Data techniques in a Stream.	
	4.3	Filtering Streams: Bloom Filter with Analysis.	
	4.4	Counting Distinct Elements in a Stream, Count-Distinct Problem, Flajolet-Martin Algorithm, Combining Estimates, Space Requirements.	
	4.5	Counting Frequent Itemsin a Stream, Sampling Methods for Streams, Frequent Itemsets in Decaying Windows.	
	4.6	Counting Ones in a Window: The Cost of ExactCounts, The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in the DGIM Algorithm, Decaying Windows.	

5		**Finding Similar Items and Clustering**	**6**
	5.1	Distance Measures: Definition of a Distance Measure, Euclidean Distances, Jaccard Distance, Cosine Distance, Edit Distance, Hamming Distance.	
	5.2	CURE Algorithm, Stream-Computing , A Stream-Clustering Algorithm, Initializing & Merging Buckets,Answering Queries.	
6		**Real-Time Big Data Models**	**8**
	6.1	PageRank Overview, Efficient computation of PageRank: PageRankIteration Using MapReduce, Use of Combiners to Consolidate the Result Vector.	
	6.2	A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering.	
	6.3	Social Networks as Graphs, Clustering of Social-Network Graphs, Direct Discovery of Communities in a social graph.	

Textbooks:	
1	Anand Rajaraman and Jeff Ullman ―Mining of Massive Datasets‖, Cambridge UniversityPress,
2	Alex Holmes ―Hadoop in Practice‖, Manning Press, Dreamtech Press.
3	Dan Mcary and Ann Kelly ―Making Sense of NoSQL‖ – A guide for managers and the restof us, Manning Press.
References:	
1	Bill Franks , ―Taming The Big Data Tidal Wave: Finding Opportunities In Huge DataStreams With Advanced Analytics‖, Wiley
2	Chuck Lam, ―Hadoop in Action‖, Dreamtech Press
3	Jared Dean, ―Big Data, Data Mining, and Machine Learning: Value Creation for BusinessLeaders and Practitioners‖, Wiley India Private Limited, 2014.
4	Jiawei Han and Micheline Kamber, ―Data Mining: Concepts and Techniques‖, Morgan Kaufmann Publishers, 3rd ed, 2010.
5	Lior Rokach and Oded Maimon, ―Data Mining and Knowledge Discovery Handbook‖, Springer, 2nd edition, 2010.
6	Ronen Feldman and James Sanger, ―The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data‖, Cambridge University Press, 2006.
7	Vojislav Kecman, ―Learning and Soft Computing‖, MIT Press, 2010

Assessment:	
Internal Assessment:	
The assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All questions carry equal marks.
3	Question 1 and question 6 will have questions from all modules. Remaining 4 questions will be based on the remaining 4 modules.
4	Only four questions need to be solved.
5	In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Course Code:	Course Title	Credit
CSDO7011	Natural Language Processing	3

Prerequisite: Artificial Intelligence and Machine Learning, Basic knowledge of Python	
Course Objectives:	
1	To understand natural language processing and to learn how to apply basic algorithms in this field
2	To get acquainted with the basic concepts and algorithmic description of the main language levels: morphology, syntax, semantics, and pragmatics
3	To design and implement various language models and POS tagging techniques
4	To design and learn NLP applications such as Information Extraction, Question answering
5	To design and implement applications based on natural language processing
Course Outcomes:	
1	To have a broad understanding of the field of natural language processing
2	To design language model for word level analysis for text processing
3	To design various POS tagging techniques
4	To design, implement and test algorithms for semantic analysis
5	To develop basic understanding of Pragmatics and to formulate the discourse segmentation and anaphora resolution
6	To apply NLP techniques to design real world NLP applications

Module		Content	Hrs
1		**Introduction**	**4**
	1.1	Origin & History of NLP, The need of NLP, Generic NLP System, Levels of NLP, Knowledge in Language Processing, Ambiguity in Natural Language, Challenges of NLP, Applications of NLP.	
2		**Word Level Analysis**	**8**
	2.1	Tokenization, Stemming, Segmentation, Lemmatization, Edit Distance, Collocations, Finite Automata, Finite State Transducers (FST), Porter	

		Stemmer, Morphological Analysis, Derivational and Reflectional Morphology, Regular expression with types.	
	2.2	N –Grams, Unigrams/Bigrams Language Models, Corpora, Computing the Probability of Word Sequence, Training and Testing.	
3		**Syntax analysis**	**8**
	3.1	Part-Of-Speech Tagging (POS) - Open and Closed Words. Tag Set for English (Penn Treebank), Rule Based POS Tagging, Transformation Based Tagging, Stochastic POS Tagging and Issues –Multiple Tags & Words, Unknown Words.	
	3.2	Introduction to CFG, Hidden Markov Model (HMM), Maximum Entropy, And Conditional Random Field (CRF).	
4		**Semantic Analysis**	**8**
	4.1	Introduction, meaning representation; Lexical Semantics; Corpus study; Study of Various language dictionaries like WordNet, Babelnet; Relations among lexemes & their senses –Homonymy, Polysemy, Synonymy, Hyponymy; Semantic Ambiguity	
	4.2	Word Sense Disambiguation (WSD); Knowledge based approach (Lesk‘s Algorithm), Supervised (Naïve Bayes, Decision List), Introduction to Semi-supervised method (Yarowsky), Unsupervised (Hyperlex)	
5		**Pragmatic & Discourse Processing**	**6**
	5.1	Discourse: Reference Resolution, Reference Phenomena, Syntactic & Semantic constraint on coherence; Anaphora Resolution using Hobbs and Cantering Algorithm	
6		**Applications (preferably for Indian regional languages)**	**5**
	6.1	Machine Translation, Information Retrieval, Question Answers System, Categorization, Summarization, Sentiment Analysis, Named Entity Recognition.	
	6.2	Linguistic Modeling – Neurolinguistics Models- Psycholinguistic Models – Functional Models of Language – Research Linguistic Models- Common Features of Modern Models of Language.	

Textbooks:	
1	Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Second Edition, Prentice Hall, 2008.
2	Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.
References:	
1	Siddiqui and Tiwary U.S., Natural Language Processing and Information Retrieval, Oxford University Press, 2008.
2	Daniel M Bikel and ImedZitouni — Multilingual natural language processing applications: from theory to practice, IBM Press, 2013.
3	Nitin Indurkhya and Fred J. Damerau, —Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.

Useful Links	
1	https://onlinecourses.nptel.ac.in/noc21_cs102/preview
2	https://onlinecourses.nptel.ac.in/noc20_cs87/preview
3	https://nptel.ac.in/courses/106105158

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course/Subject Name	Credits
CSDO7012	AI for Healthcare	3

Course Prerequisites:	
Artificial Intelligence, Machine Learning	
Course Objectives: The course aims	
1	To understand the need and significance of AI and ML for Healthcare.
2	To study advanced AI algorithms for Healthcare.
3	To learn Computational Intelligence techniques .
4	To understand evaluation metrics and ethics in intelligence for Healthcare systems,
5	To learn various NLP algorithms and their application in Healthcare,
6	To investigate the current scope, implications of AI and ML for developing futuristic Healthcare Applications.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Understand the role of AI and ML for handling Healthcare data.
2	Apply Advanced AI algorithms for Healthcare Problems.
3	Learn and Apply various Computational Intelligence techniques for Healthcare Application.
4	Use evaluation metrics for evaluating healthcare systems.
5	Develop NLP applications for healthcare using various NLP Techniques..
6	Apply AI and ML algorithms for building Healthcare Applications

Module		Topics	Hours
1		**Introduction**	06
	1.1	Overview of AI , ML and DL ,A Multifaceted Discipline, Applications of AI in Healthcare -Prediction, Diagnosis, personalized treatment and behavior modification, drug discovery, followup care etc,	
	1.2	Realizing potential of AI in healthcare, Healthcare Data - Use Cases.	
2		**AI, ML, Deep Learning and Data Mining Methods for Healthcare**	08
	2.1	Knowledge discovery and Data Mining, ML, Multi classifier Decision Fusion, Ensemble Learning, Meta-Learning and other Abstract Methods.	
	2.2	Evolutionary Algorithms, Illustrative Medical Application-Multiagent Infectious Disease Propagation and Outbreak Prediction, Automated Amblyopia Screening System etc.	
	2.3	Computational Intelligence Techniques, Deep Learning, Unsupervised learning, dimensionality reduction algorithms.	
3		**Evaluating learning for Intelligence**	04
	3.1	Model development and workflow, evaluation metrics, Parameters and Hyperparameters, Hyperparameter tuning algorithms, multivariate testing, Ethics of Intelligence.	
4		**Natural Language Processing in Healthcare**	**08**
	4.1	NLP tasks in Medicine, Low-level NLP components, High level NLP components, NLPMethods.	

	4.2	Clinical NLP resources and Tools, NLP Applications in Healthcare. Model Interpretability using Explainable AI for NLP applications.	
5		**Intelligent personal Health Record**	**05**
	5.1	Introduction, Guided Search for Disease Information, Recommending SCA's. Recommending HHP's , Continuous User Monitoring.	
6		**Future of Healthcare using AI**	**08**
	6.1	Evidence based medicine, Personalized Medicine, Connected Medicine, Digital Health and Therapeutics, Conversational AI, Virtual and Augmented Reality, Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	
	6.2	Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	

Textbooks:	
1	Arjun Panesar, "Machine Learning and AI for Healthcare", A Press.
2	Arvin Agah, "Medical applications of Artificial Systems ", CRC Press

References:	
1	Erik R. Ranschaert Sergey Morozov Paul R. Algra, "Artificial Intelligence in medicalImaging- Opportunities, Applications and Risks", Springer
2	Sergio Consoli Diego Reforgiato Recupero Milan Petković,"Data Science for Healthcare-Methodologies and Applications", Springer
3	Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, "Emerging technologies for health and medicine", Wiley.
4	Ton J. Cleophas • Aeilko H. Zwinderman, "Machine Learning in Medicine- Complete Overview", Springer

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Course Code:	Course Title	Credit
CSDO7013	Neural Networks and Fuzzy Systems	3

Prerequisite: Engineering Mathematics, Data Structures and Algorithm, Python Programming			
Course Objectives:			
1	To relate to the basic terminologies with respect to Fuzzy set theory.		
2	To analyze and interpret fuzzy logic principles, relations and operations.		
3	To recognize various components of Associative Memory Networks.		
4	To have basic understanding of Unsupervised learning through Networks.		
5	To understand Special networks and its applications in soft computing.		
6	To infer the significance of Hybrid computing.		
Course Outcomes: After successful completion of the course student will be able to			
1	Acquire basic knowledge of fuzzy set theory properties and relations.		
2	Implement Fuzzy operations towards Fuzzy-rule creations.		
3	Gain familiarity with the training and implementation of Associative Memory Network.		
4	Understand the architecture and basics components of Unsupervised learning networks.		
5	Analyze the significance and working of the Special Networks.		
6	Interpret Hybrid System to analyze the Principles of Soft computing in Neuro-Fuzzy applications.		
Module		**Content**	**Hrs**
1.0		**Fuzzy Set Theory**	**07**
	1.1	**Introduction to soft and hard computing Fuzzy Sets:** Basic definition and terminology of fuzzy sets, Classic set operations; Fuzzy set operations- Union, Intersection, complement, Difference; Properties of fuzzy sets.	
	1.2	**Fuzzy relations:** Cartesian product of relation, Classica Relation, Cardinality of fuzzy relations, Operations on Fuzzy relations, Properties of Fuzzy relations, Fuzzy composition, Tolerance and Equivalence Relationship.	
	1.3	**Membership Functions:** Features of Membership Functions, Fuzzification, Methods of membership value assignments.	
2.0		**Fuzzy Rules, Reasoning, and Inference System**	**08**

	2.1	**Defuzzification:** Lambda-Cuts for Fuzzy Sets; Lambda-Cuts for Fuzzy Relations; Defuzzification methods: Max-Membership Principles, Centroid Method, Weighted Average Method, Mean-Max Membership, Center of Sums, Center of Largest Area, First of Maxima.	
	2.2	**Fuzzy Arithmetic and Rules:** Fuzzy arithmetic, Fuzzy measures, Measures of Fuzziness, Truth Value and Tables in Fuzzy Logic, Fuzzy Propositions, Formation of rules, Decomposition of rules, Fuzzy Reasoning.	
	2.3	**Fuzzy Inference System (FIS):** Mamdani FIS, Sugeno FIS, Comparison between Mamdani and Sugeno FIS.	
3.0		**Associative Memory Networks**	**06**
	3.1	**Introduction:** Basics of associative memory networks, Training algorithms for Pattern Association.	
	3.2	**Types of Networks:** Radial basis function network : architecture training algorithm**,** Auto-associative Memory Network – Architecture, Flowchart of training process, Training algorithm, Testing algorithm, Hetero- associative Memory Network- Architecture and Testing algorithm, Bidirectional Associative Memory(BAM) Network- Architecture, Discrete BAM, Continuous BAM.	
4.0		**Unsupervised Learning Networks**	**08**
	4.1	**Introduction** Fixed weight competitive nets**,** Maxnet, Maxican net, Hamming Network	
	4.2	**Kohonen Self- Organizing Feature Maps:** Basic concepts, Architecture, Flowchart, Algorithms, Kohonen Self-Organizing Motor map Training algorithm.	
	4.3	**Adaptive resonance Theory:** Architecture, Fundamental Operating principles, a Algorithms, Adaptive Resonance Theory I – Architecture, Flowchart of Training process, Training algorithm, Adaptive Resonance Theory 2 - Architecture, Algorithm, Flowchart, Training algorithm, Sample Values of Parameter.	
5.0		**Special Network**	**05**
	5.1	**Introduction:** Boltzmann Machine, Gaussian Machine, Probabilistic neural nets Spatio-Temporal connection network model, Ensemble neural model Extreme learning machine models, Online, Pruned, Improved Application of ELM	

6.0		Hybrid Computing	**05**
	6.1	**Neuro-Fuzzy Hybrid Systems:** Introduction to Neuro-Fuzzy systems, Comparison of Fuzzysystems and Neural networks, Characteristics of Neuro-Fuzzy systems, Classification of Neuro-Fuzzy systems. Introduction to Adaptive Neuro-Fuzzy Inference System (ANIFS), ANFS Architecture, Constraints of ANFIS, ANFIS as a Universal Approximator.	

Textbooks:	
1	S.N. Sivanandan and S.N. Deepa, Principles of Soft Computing, Wiley India, 2007, ISBN: 10: 81- 265-1075-7.
2	J.-S. R. Jang, C. –T. Sun, E. Mizutani, Neuro-Fuzzy and Soft Computing, A Computational Approach to Learning and Machine Intelligence, PHI Learning Private Limited-2014
3	Neural Networks: A Classroom Approach, Satish Kumar, Tata McGraw-Hill Education, 2004/2007
4	Simon Haykin, Neural Networks A Comprehensive Foundation, Second Edition, Pearson Education-2004
5	David E. Goldberg, Genetic Algorithms, in search, optimization and Machine Learning, Pearson

References:	
1	Anupam Shukla, Ritu Tiwari, Rahul Kala, Real Life Applications of Soft Computing, CRC Press, Taylor & Francis Group, 2010.
2	Genetic Algorithms and Genetic Programming Modern Concepts and Practical Applications © 2009 Michael Affenzeller, Stephan Winkler, Stefan Wagner, and Andreas Beham, CRC Press
3	Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms And Applications, Pearson

Digital References:

https://onlinecourses.nptel.ac.in/noc22_ee21/preview

https://onlinecourses.nptel.ac.in/noc23_ge15/preview

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Course Code:	Course Title	Credit
CSDO7021	User Experience Design with VR	3

Prerequisite: Web Technologies; Software Engineering	
Course Objectives:	
1	To study and understand importance of user experience design principles
2	To understand elements of user experience design
3	To encourage students to participate in designing futuristic applications
4	To understand the need and significance of Virtual Reality
5	To understand the technical and engineering aspects of virtual reality systems
Course Outcomes:	
1	To Apply principles of user experience
2	To apply emerging and established technologies to enhance User Experience design
3	To create interface for international standards with ethics
4	To evaluate user experience.
5	Describe how VR systems work and list the applications of VR
6	Design and implementation of the hardware that enables VR systems to be built

Module		Content	Hrs
1		**Introduction**	**04**
	1.1	Introduction to interface design, Understanding and conceptualizing Interface, understanding user's conceptual cognition, Core Elements of User Experience, Working of UX elements	
2		**The UX Design Process – Understanding Users & Structure:**	**08**
	2.1	Defining the UX, Design Process and Methodology, Understanding user requirements and goals, Understanding the Business Requirements/Goals, User research, mental models, wireframes, prototyping, usability testing.	
	2.2	Visual Design Principles , Information Design and Data Visualization Interaction Design, UI Elements and Widgets, Screen Design and Layouts	

3		**UX Design Process: Prototype and Test**	**06**
	3.1	Testing your Design, Usability Testing, Types of Usability Testing , Usability Testing Process, Preparing and planning for the Usability Tests,	
	3.2	Prototype your Design to Test, Introduction of prototyping tools, conducting Usability Test, communicating Usability Test Results	
4		**UX Design Process: Iterate/ Improve and Deliver**	**05**
	4.1	Understanding the Usability Test, findings, Applying the Usability Test, feedback in improving the design.	
	4.2	Communication with implementation team. UX Deliverables to be given to implementation team	
5		**Introduction to Virtual Reality**	**08**
	5.1	Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality	
	5.2	Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR	
6		**Applying Virtual Reality**	**08**
	6.1	Virtual reality: the medium, Form and genre, What makes an application a good candidate for VR, Promising application fields, Demonstrated benefits of virtual reality, More recent trends in virtual reality application development, A framework for VR application development	

Textbooks:	
1	Interaction Design, Beyond Human Computer Interaction, Rogers, Sharp, Preece Wiley India Pvt Ltd.
2	The essentials of Interaction Design, Alan Cooper, Robert Reimann, David Cronin
3	Designing The user Interface by Shneiderman, Plaisant, Cohen, Jacobs Pearson
References:	

1	The Elements of User Experience by Jesse James Garrett
2	Don’t make me think, by Steve Krug
3	Observing the User Experience: A Practitioner's Guide to User Research by Mike Kuniavsky

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Useful Links	
1	https://archive.nptel.ac.in/courses/124/107/124107008/
2	https://nptel.ac.in/courses/106106138
3	https://www.coursera.org/specializations/virtual-reality

Course Code:	Course Title	Credit
CSDO7022	Blockchain Technologies	3

Prerequisite: Cryptography and Distributes systems	
Course Objectives:	
1	To get acquainted with the concept of Distributed ledger system and Blockchain.
2	To learn the concepts of consensus and mining in Blockchain through the Bitcoin network.
3	To understand Ethereum and develop-deploy smart contracts using different tools and frameworks.
4	To understand permissioned Blockchain and explore Hyperledger Fabric.
5	To understand different types of crypto assets.
Course Outcomes:	
1	Describe the basic concept of Blockchain and Distributed Ledger Technology.
2	Interpret the knowledge of the Bitcoin network, nodes, keys, wallets and transactions
3	Implement smart contracts in Ethereum using different development frameworks.
4	Develop applications in permissioned Hyperledger Fabric network.
5	Interpret different Crypto assets and Crypto currencies
6	Analyze the use of Blockchain with AI, IoT and Cyber Security using case studies.

Module		Content	Hrs
1		**Introduction to Blockchain**	**5**
	1.1	**Distributed Ledger Technologies:** Introduction to blockchain: History, evolution, fundamentals concepts, components, types. **Block in a Blockchain:** Structure of a Block, Block Header Hash and Block Height, The Genesis Block, Linking Blocks in the Blockchain, Merkle Tree.	
2		**Consensus Protocol and Bitcoin blockchain**	**6**

	2.1	**Consensus**: Byzantine Generals Problem, consensus algorithms: PoW, PoS, PoET, PoA, LPoS, pBFT, Proof-of-Burn (PoB), Life of a miner, Mining difficulty, Mining pool and its methods.	
	2.2	**Bitcoin**: What is Bitcoin, history of Bitcoin, Bitcoin Common terminologies: keys, addresses and nodes, Bitcoin mining, hashcash, Block propagation and relay, bitcoin scripts, transaction in the bitcoin network.	
3		**Ethereum and Smart Contracts**	**8**
	3.1	**Ethereum:** History, Components, Architecture of Ethereum, Consensus, Miner and mining node, Ethereum virtual machine, Ether, Gas, Transactions, Accounts, Patricia Merkle Tree, Swarm, Whisper and IPFS, complete transaction working and steps in Ethereum, Case study of Ganache for Ethereum blockchain. Exploring etherscan.io and ether block structure, Comparison between Bitcoin and Ethereum	
	3.2	**Smart Contracts:** history, characteristics, working of smart contracts, types, Oracles, Structure & Limitations. **Solidity programming:** set-up tools and installation, Basics, functions, Visibility and Activity Qualifiers, Ethereum networks, solidity compiler, solidity files and structure of contracts, data types, storages, array, functions, Developing and executing smart contracts in Ethereum. Smart Contracts Use cases, Opportunities and Risk.	
4		**Private and Consortium blockchains**	**9**
	4.1	**Introduction to Private Blockchain:** Key characteristics, need, Examples of Private and Consortium blockchains, Smart contracts in private blockchain.	
	4.2	Introduction to Hyperledger, Tools and Frameworks, Hyperledger Fabric, Comparison between Hyperledger Fabric & Other Technologies. Hyperledger Platform, Paxos and Raft consensus, Ripple and Corda blockchains, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT.	
5		**Cryptocurrencies and digital tokens**	**6**

	5.1	Cryptocurrency basics, types, usage, ERC20 and ERC721 Tokens, comparison between ERC20 & ERC721, ICO: basics and related terms, launching an ICO, pros and cons, evolution and platforms, STO, Different Crypto currencies, Defi, Metaverse, Types of cryptocurrencies. Bitcoin, Altcoin, and Tokens (Utility and Security), Cryptocurrency wallets: Hot and cold wallets, Cryptocurrency usage, Transactions in Blockchain, UTXO and double spending problem	
6		**Blockchain applications, Tools and case studies**	**5**
	6.1	**Applications of Blockchain**: Various domains including Education, Energy, Healthcare, real-estate, logistics, supply chain. **Tools:** Corda, Ripple, Quorum and other Emerging Blockchain Platforms, Case Study on any of the Blockchain Platforms.	

Textbooks:	
1.	Blockchain Technology, Chandramouli Subramanian, Asha A George, Abhillash K. A and Meena Karthikeyen, Universities press.
2.	Solidity Programming Essentials: A beginner's Guide to Build Smart Contracts for Ethereum and Blockchain, Ritesh Modi, Packt publication
3.	Hyperledger Fabric In-Depth: Learn, Build and Deploy Blockchain Applications Using Hyperledger Fabric, Ashwani Kumar, BPB publications
4.	Cryptoassets: The Innovative Investor‘s Guide to Bitcoin and Beyond, Chris Burniske & Jack Tatar.
5	Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O‘reilly.
References:	
1.	Mastering Bitcoin, programming the open Blockchain‖, 2nd Edition by Andreas M. Antonopoulos, June 2017, Publisher(s): O'Reilly Media, Inc. ISBN: 9781491954386.
2.	Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
3.	Blockchain Technology: Concepts and Applications, Kumar Saurabh and Ashutosh Saxena, Wiley Publication.

4.	The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrencies and the Technology that Powers Them, Antony Lewis. for Ethereum and Blockchain, Ritesh Modi, Packt publication. University of Mumbai, B. E. (Information Technology), Rev 2016 276

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Useful Links	
1	NPTEL courses: Blockchain and its Applications, Blockchain Architecture Design and Use Cases
2	https://ethereum.org/en/
3	https://www.trufflesuite.com/tutorials
4	https://hyperledger-fabric.readthedocs.io/en/release-2.2/
5	**Blockchain demo:** https://andersbrownworth.com/blockchain/
6	**Blockchain Demo:** Public / Private Keys & Signing: https://andersbrownworth.com/blockchain/public-private-keys/

Course Code:	Course Title	Credit
CSDO7023	Game Theory for Data Science	3

Prerequisite: Probability Algebra

Sr. No.	Course Objectives
1.	To introduce the student to the notion of a game, its solutions concepts, and other basic notions and tools of game theory, and the main applications for which they areappropriate, including electronic trading markets.
2.	To formalize the notion of strategic thinking and rational choice by using the toolsof game theory, and to provide insights into using game theory in modeling applications.
3.	To draw the connections between game theory, computer science, and economics,especially emphasizing the computational issues.
4.	To introduce contemporary topics in the intersection of game theory, computerscience, and economics.
5.	To apply game theory in searching, auctioning and trading.

Sr.No.	Course Outcomes
On successful completion, of course, learner/student will be able to:	
1.	Analyze and Discuss the notion of a strategic game and equilibria and identify the characteristics of main applications of these concepts.
2.	Discuss the use of Nash Equilibrium for other problems. Identify key strategic aspectsand based on these be able to connect them to appropriate game theoretic concepts given a real world situation.
3.	Identify some applications that need aspects of Bayesian Games. Implement a typicalVirtual Business scenario using Game theory.
4.	Identify and discuss working principle of Non-Cooperative Games
5.	Discuss the Mechanism for Design Aggregating Preferences
6.	Identify and discuss working principle : Repeated Games

Module		Detailed Content	Hours
0		**Prerequisite :** Probability , Algebra	1
1		**Introduction**	6
	1.1	Making rational choices: basics of Games – strategy – preferences – payoffs – Mathematical basics – Game theory– Rational Choice – Basic solution concepts-non-cooperative versus cooperative games – Basic computational issues – finding equilibria and learning in gamesTypical application areas for game theory (e.g. Google's sponsored search, eBay auctions, electricity trading markets).	
2		**Games with PerfectInformation**	7
	2.1	Strategic games – prisoner's dilemma, matching pennies -Nash equilibria – theory and illustrations – Cournot's and Bertrand models of oligopoly – auctions – mixed strategy equilibrium – zero-sum games – Extensive Games with Perfect Information – repeated games (prisoner's dilemma) – subgame perfect Nash equilibrium; computational issues.	
3		**Games with Imperfect Information**	6
	3.1	Games with Imperfect Information – Bayesian Games – Motivational Examples – General Definitions – Informationaspects – Illustrations – Extensive Games with Imperfect – Information – Strategies – Nash Equilibrium – Beliefs and sequential equilibrium – Illustrations – Repeated Games – The Prisoner's Dilemma – Bargaining.	
4		**Non-CooperativeGame Theory**	7
	4.1	Non-cooperative Game Theory – Self-interested agents – Games in normal form – Analyzing games: from optimalityto equilibrium – Computing Solution Concepts of Normal –Form Games – Computing Nash equilibria of two-player, zero-sum games –Computing Nash equilibria of two-player,generalsum games – Identifying dominated strategies	
5		**Mechanism DesignAggregating Preferences:**	6
	5.1	Social Choice – Formal Model – Voting – Existence of social functions – Ranking systems – Protocols for StrategicAgents: Mechanism Design – Mechanism design with unrestricted preferences – Efficient mechanisms – Vickrey and VCG mechanisms (shortest paths) – Combinatorial auctions – profit maximization Computational applications of mechanism design – applications in Computer Science –Google's sponsored search – eBay auctions – K-armed bandits.	
6		**Repeated Games**	6
	6.1	Repeated games: The Prisoner's Dilemma , The main idea , Preferences ,Infinitely repeated games, Strategies ,Some Nash equilibria of the infinitely repeated Prisoner's Dilemma , Nash	

		equilibrium payoffs of the infinitely repeated Prisoner's Dilemma when the players are patient ,Subgame perfect equilibria and the one-deviation property	

Textbooks:	
1	An Introduction to Game Theory by Martin J. Osborne
2	M. J. Osborne, An Introduction to Game Theory. Oxford University Press, 2004

References:	
1	M. Machler, E. Solan, S. Zamir, Game Theory, Cambridge University Press, 2013.
2	N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani (Editors), Algorithmic GameTheory. Cambridge University Press, 2007.
3	A.Dixit and S. Skeath, Games of Strategy, Second Edition. W W Norton & Co Inc,2004.
4	YoavShoham, Kevin Leyton-Brown, Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge University Press 2008.
5	Zhu Han, DusitNiyato, WalidSaad, TamerBasar and Are Hjorungnes, "Game Theoryin Wireless and Communication Networks", Cambridge University Press, 2012.
6	Y.Narahari, "Game Theory and Mechanism Design", IISC Press, World Scientific.

Digital References:
1. https://nptel.ac.in/courses/110104063
2. https://onlinecourses.nptel.ac.in/noc19_ge32/preview

<u>Assessment</u>:
Internal Assessment:
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Course Code	Course Name	Credits
ILO7011	Product Life Cycle Management	03

Course Objectives:	
1	To familiarize the students with the need, benefits and components of PLM
2	To acquaint students with Product Data Management & PLM strategies
3	To give insights into new product development program and guidelines for designing and developing a product
4	To familiarize the students with Virtual Product Development
Course Outcomes:	
1	Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2	Illustrate various approaches and techniques for designing and developing products.
3	Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4	Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Module		Contents	Hrs
1	1.1	**Introduction to Product Lifecycle Management (PLM)** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications.	10
	1.2	**PLM Strategies** Industrial strategies, Strategy elements, its identification, selection andimplementation, Developing PLM Vision and PLM Strategy, Change management for PLM	
2	2.1	**Product Design** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Propertiesand Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	09

3	3.1	**Product Data Management (PDM):** Product and Product Data, PDM systems andimportance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	05
4	4.1	**Virtual Product Development Tools** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	05
5	5.1	**Integration of Environmental Aspects in Product Design** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	05
6	6.1	**Life Cycle Assessment and Life Cycle Cost Analysis** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	05

Text Book & References:	
1	John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2	Fabio Giudice, Guido La Rosa, AntoninoRisitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3	SaaksvuoriAntti, ImmonenAnselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4	Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

<u>Assessment</u>:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either aclass test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course Name	Credits
ILO7012	Reliability Engineering	03

Course Objectives:	
1	To familiarize the students with various aspects of probability theory
2	To acquaint the students with reliability and its concepts
3	To introduce the students to methods of estimating the system reliability of simple and complex systems
4	To understand the various aspects of Maintainability, Availability and FMEA procedure
Course Outcomes:	
1	Understand and apply the concept of Probability to engineering problems
2	Apply various reliability concepts to calculate different reliability parameters
3	Estimate the system reliability of simple and complex systems
4	Carry out a Failure Mode Effect and Criticality Analysis

Module		Contents	Hours
01	1.1	**Probability theory** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem.	08
	1.2	**Probability Distributions** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance.	
	1.3	**Measures of Dispersion** Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	
02	2.1	**Reliability Concepts** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve.	08
	2.2	**Failure Data Analysis** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions.	
	2.3	**Reliability Hazard Models** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	
03	3.1	**System Reliability** System Configurations: Series, parallel, mixedconfiguration, k out of n structure, Complex systems.	05
04	4.1	**Reliability Improvement** Redundancy Techniques: Element redundancy, Unitredundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path	08

		method, Decomposition method.	
05	5.1	**Maintainability and Availability** System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	05
06	6.1	**Failure Mode, Effects and Criticality Analysis** Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	05

Text Book & References:

1	L.S. Srinath, "Reliability Engineering", Affiliated East-Wast Press (P) Ltd., 1985.
2	Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3	B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4	P.D.T. Conor, "Practical Reliability Engg.", John Wiley & Sons, 1985.
5	K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6	Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd.

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either aclass test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course Name	Credits
ILO7013	Management Information System	03

Course Objectives:	
1	The course is blend of Management and Technical field.
2	Discuss the roles played by information technology in today's business and define varioustechnology architectures on which information systems are built
3	Define and analyze typical functional information systems and identify how they meet the needsof the firm to deliver efficiency and competitive advantage
4	Identify the basic steps in systems development
Course Outcomes:	
1	Explain how information systems Transform Business
2	Identify the impact information systems have on an organization
3	Describe IT infrastructure and its components and its current trends
4	Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
5	Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Module		Detailed Contents	Hrs
01	1.1	**Introduction To Information Systems (IS)** Computer Based Information Systems,Impact of IT on organizations, Imporance of IS to Society. Organizational Strategy, Competitive Advantages and IS.	4
02	2.1 2.2	**Data and Knowledge Management** Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. **Business intelligence (BI)** Managers and Decision Making, BI for Data analysis and Presenting Results	7
03	3.1	**Ethical issues and Privacy** Information Security. Threat to IS, and SecurityControls	7
04	4.1	**Social Computing (SC)** Web 2.0 and 3.0, SC in business-shopping, Marketing,Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
05	5.1	Computer Networks Wired and Wireless technology, Pervasive computing,Cloud computing model.	6
06	6.1	**Information System within Organization** Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	8

Text Book & References:	
1	Kelly Rainer, Brad Prince,Management Information Systems, Wiley

2	K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007.
3	D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall,2008

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either aclass test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course Name	Credits
ILO7014	Design of Experiments	03

Course Objectives:	
1	To understand the issues and principles of Design of Experiments (DOE)
2	To list the guidelines for designing experiments
3	To become familiar with methodologies that can be used in conjunction with experimental designs forrobustness and optimization

Course Outcomes:	
1	Plan data collection, to turn data into information and to make decisions that lead to appropriate action
2	Apply the methods taught to real life situations
3	Plan, analyze, and interpret the results of experiments

Module		Contents	Hours
01	1.1	Introduction Strategy of Experimentation, Typical Applications of Experimental Design Guidelines for Designing Experiments Response Surface Methodology	06
02	2.1	Fitting Regression Models Linear Regression Models, Estimation of the Parameters in Linear Regression, Models Hypothesis Testing in Multiple Regression, Confidence Intervals in Multiple RegressionPrediction of new response observation, Regression model diagnostics, Testing for lack of fit	08
03	3.1	Two-Level Factorial Designs The 2^2 Design, The 2^3 Design, The General2^k Design, A Single Replicate of the 2^k Design, The Addition of Center Points to the 2^k Design, Blocking in the 2^k Factorial Design, Split-Plot Designs	07
04	4.1	Two-Level Fractional Factorial Designs The One-Half Fraction of the 2^k Design, The One-Quarter Fraction of the 2^k Design The General 2^{k-p} Fractional Factorial Design Resolution III Designs Resolution IV and V Designs Fractional Factorial Split-Plot Designs	07
05	5.1	Response Surface Methods and Designs Introduction to Response Surface MethodologyThe Method of Steepest Ascent Analysis of a Second-Order Response Surface Experimental Designs for Fitting Response Surfaces	07
06	6.1	**Taguchi Approach** Crossed Array Designs and Signal-to-Noise , Ratios Analysis Methods, Robust design examples	04

Text Book & References:	
1	Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition,John Wiley & Sons, New York, 2001
2	D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley &Sons, New York,2001
3	George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design,Innovation and Discovery, 2nd Ed. Wiley

4	W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc.ISBN: 0-471-39054-2
5	Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean,and

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either aclass test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course Name	Credits
ILO7015	Operations Research	03

Course Objectives:	
1	Formulate a real-world problem as a mathematical programming model.
2	Understand the mathematical tools that are needed to solve optimization problems.
3	Use mathematical software to solve the proposed models.
Course Outcomes:	
1	Understand the theoretical workings of the simplex method, the relationship between a linear programand its dual, including strong duality and complementary slackness.
2	Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimalsolution as the data change.
3	Solve specialized linear programming problems like the transportation and assignment problems, solvenetwork models like the shortest path, minimum spanning tree, and maximum flow problems.
4	Understand the applications of integer programming and a queuing model and compute importantperformance measures

Module		Contents	Hrs
01	1.1	**Introduction to Operations Research** Introduction, Structure of the Mathematical Model, Limitations of Operations Research	14
	1.2	**Linear Programming** Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis	
	1.3	**Transportation Problem** Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method.	
	1.4	**Assignment Problem** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem	
	1.5	**Integer Programming Problem** Introduction, Types of Integer Programming Problems,Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	
02	2.1	**Queuing models**: queuing systems and structures, single server and multi-servermodels, Poisson input, exponential service, constant rate service, finite and infinite population	05

03	3.1	**Simulation** Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	05
04	4.1	**Dynamic programming** Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	05
05	5.1	**Game Theory** Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategyfor 2 X 2 games.	05
06	6.1	**Inventory Models** Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05

Text Book & References:

1	Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2	Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", JohnWilley and Sons, 2nd Edition, 2009.
3	Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4	Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5	Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either aclass test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course Name	Credits
ILO7016	Cyber Security and Laws	03

Course Objectives:	
1	To understand and identify different types cybercrime and cyber law
2	To recognized Indian IT Act 2008 and its latest amendments
3	To learn various types of security standards compliances
Course Outcomes:	
1	Understand the concept of cybercrime and its effect on outside world
2	Interpret and apply IT law in various legal issues
3	Distinguish different aspects of cyber law
4	Apply Information Security Standards compliance during software design and development

Module		Contents	Hrs
01	1.1	**Introduction to Cybercrime** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and theIndian ITA 2000, A global Perspective on cybercrimes.	4
02	2.1	**Cyber offenses & Cybercrime** How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Bot nets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	9
03	3.1	**Tools and Methods Used in Cyber line** Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
04	4.1	**The Concept of Cyberspace** E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of CyberLaw ,The Intellectual Property Aspect in Cyber Law , The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, GlobalTrends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian CyberLaw	8
05	5.1	**Indian IT Act.** Cyber Crime and Criminal Justice : Penalties, Adjudication and Appeals Under the ITAct, 2000, IT Act. 2008 and its Amendments	6
06	6.1	**Information Security Standard compliances** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

Text Book & References:	
1	Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2	The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3	The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4	Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5	Nina Godbole, *Information Systems Security,* Wiley India, New Delhi
6	Kennetch J. Knapp, *Cyber Security &Global Information Assurance* Information Science Publishing.
7	William Stallings*, Cryptography and Network Security,* Pearson Publication
8	Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9	Website for more information, A Compliance Primer for IT professional: https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals- 33538

Assessment:	
Internal Assessment:	
Assessment consists of two tests out of which; one should be compulsory class test and the other is either aclass test or assignment on live problems or course project.	
End Semester Theory Examination: Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course Name	Credits
ILO7017	Disaster Management and Mitigation Measures	03

Course Objectives:	
1	To understand physics and various types of disaster occurring around the world
2	To identify extent and damaging capacity of a disaster
3	To study and understand the means of losses and methods to overcome /minimize it.
4	To understand role of individual and various organization during and after disaster
5	To understand application of GIS in the field of disaster management
6	To understand the emergency government response structures before, during and afterdisaster
Course Outcomes:	
1	Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
2	Plan of national importance structures based upon the previous history.
3	Get acquainted with government policies, acts and various organizational structureassociated with an emergency.
4	Get to know the simple do's and don'ts in such extreme events and act accordingly.

Module		Contents	Hours
01	1.1	**Introduction** Definition of Disaster, hazard, global and Indian scenario, general perspective,importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
02	2.1	**Natural Disaster:** Meaning and nature of natural disaster, Flood, Flash flood, drought,cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion	09
	2.2	**Manmade Disasters** Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	
03	3.1	**Disaster management** Meaning, concept, importance, objective of disastermanagement policy, disaster risks in India, Paradigm shift in disaster management.	06
	3.2	**Policy and administration** Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entireprocess.	
04	4.1	**Institutional Framework for Disaster Management in India** Importance of public awareness, Preparation and execution of emergency management programme.Scope and responsibilities of National Institute	06

		of Disaster Management (NIDM) and National disaster management authority (NDMA) in India.Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations.	
	4.2	Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	
05	5.1	**Financing Relief Measures** Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrenceof various disasters, Ways to approach these teams. International relief aid agencies and their role in extreme events.	09
06	6.1	**Preventive and Mitigation Measures** Pre-disaster, during disaster and post-disaster measures in some events in general Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments,Bio shield, shelters, early warning and communication	06
	6.2	**Non Structural Mitigation** Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. Do's and don'ts in case of disasters and effective implementation of relief aids.	

Text Book & References:

1	'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2	'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S.Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3	'Introduction to International Disaster Management' by Damon Copolla, Butterworth HeinemannElseveir Publications.
4	'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5	'Disaster management & rehabilitation' by Rajdeep Dasgupta, Mittal Publications, New Delhi.
6	'Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7	Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications. (Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either aclass test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course Name	Credits
ILO7018	Energy Audit and Management	03

Course Objectives:	
1	To understand the importance energy security for sustainable development and thefundamentals of energy conservation.
2	To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
3	To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.
Course Outcomes:	
1	To identify and describe present state of energy security and its importance.
2	To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
3	To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4	To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
5	To analyze the data collected during performance evaluation and recommend energy savingmeasures

Module		Detailed Contents	Hours
01	1.1	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act- 2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
02	2.1	**Energy Audit Principles:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis.	08
	2.2	**Financial analysis techniques:** Simple payback period, NPV, Return on investment (ROI),Internal rate of return (IRR)	
03	3.1	**Energy Management and Energy Conservation in Electrical System** Electricitybilling, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings.	10
	3.2	**Energy efficiency measures in lighting system, Lighting control** Occupancy sensors, daylight integration, and use of intelligent	

		controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	
04	4.1	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
05	5.1	**Energy Performance Assessment** On site Performance evaluation techniques, Case studies based on: Motors and variablespeed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	04
06	6.1	**Energy conservation in Buildings** Energy Conservation Building Codes (ECBC): Green Building, LEED rating,Application of Non-Conventional and Renewable Energy Sources	03

Text Book & References:

1	Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2	Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3	Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4	Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata EnergyResearch Institute (TERI).
5	Energy Management Principles, C.B.Smith, Pergamon Press
6	Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7	Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8	www.energymanagertraining.com
9	www.bee-india.nic.in

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either aclass test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Course Code	Course Name	Credits
ILO7019	Development Engineering	03

Course Objectives:	
1	To familiarise the characteristics of rural Society and the Scope, Nature and Constraints of rural Development
2	To provide an exposure to implications of 73rdCAA on Planning, Development and Governance of RuralAreas
3	An exploration of human values, which go into making a 'good' human being, a 'good' professional, a 'good' society and a 'good life' in the context of work life and the personal life of modern Indian professionals
4	To familiarise the Nature and Type of Human Values relevant to Planning Institutions
Course Outcomes:	
1	Demonstrate understanding of knowledge for Rural Development.
2	Prepare solutions for Management Issues.
3	Take up Initiatives and design Strategies to complete the task
4	Develop acumen for higher education and research.
5	Demonstrate the art of working in group of different nature
6	Develop confidence to take up rural project activities independently

Module		Contents	Hrs
1	1.1	Introduction to Rural Development Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraintsfor rural development. Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	**08**
2	2.1	Post-Independence rural Development Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people's participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development.	**06**
3	3.1	Rural Development Initiatives in Five Year Plans Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Specialcomponent plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development	**07**

4	4.1	Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XIschedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalizedPanchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	04
5	5.1	Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral andethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom	10
6	6.1	Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	04

Text Book & References:

1	ITPI, Village Planning and Rural Development, ITPI, New Delhi
2	Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3	GoI, Constitution (73rdGoI, New Delhi Amendment) Act, GoI, New Delhi
4	Planning Commission, Five Year Plans, Planning Commission
5	Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission New Delhi
6	Planning Guide to Beginners
7	Weaver, R.C., The Urban Complex, Doubleday
8	Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington
9	How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150
10	Watson, V. Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theoryand Practice, Vol. 4, No.4, pp.395 – 407

Assessment:

Internal Assessment:

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papersof end semester examination. **In question paper weightage of each module will be proportional to number ofrespective lecture hours as mention in the syllabus.**

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus

Lab Code	Lab Name	Credit
CSL701	Deep Learning Lab	1

Prerequisite: Python Programming, Engineering Mathematics	
Lab Objectives:	
1	To implement basic neural network models.
2	To implement various training algorithms for feedforward neural networks.
3	To design deep learning models for supervised, unsupervised and sequence learning.
Lab Outcomes: At the end of the course, the students will be able to	
1	Implement basic neural network models.
2	Design and train feedforward neural networks using various learning algorithms and optimize model performance.
3	Build and train deep learning models such as Autoencoders, CNNs, RNN, LSTM,GRU etc.

Suggested List of Experiments	
1.	**Based on Module 1 using Virtual Lab**
	1. Implement Multilayer Perceptron algorithm to simulate XOR gate. 2. To explore python libraries for deep learning e.g. Theano, TensorFlow etc.
2	**Module 2 (Any Two)**
	3. Apply any of the following learning algorithms to learn the parameters of the supervised single layer feed forward neural network. a. Stochastic Gradient Descent b. Mini Batch Gradient Descent c. Momentum GD d. Nestorev GD e. Adagrad GD f. Adam Learning GD 4. Implement a backpropagation algorithm to train a DNN with at least 2 hidden layers. 5.Design and implement a fully connected deep neural network with at least 2 hidden layers for a classification application. Use appropriate Learning Algorithm, output function and loss function.
3.	**Module 3 (Any One)**

	6. Design the architecture and implement the autoencoder model for Image Compression. 7. Design the architecture and implement the autoencoder model for Image denoising.
4	**Module 4 (Any One)**
	8. Design and implement a CNN model for digit recognition application. 9. Design and implement a CNN model for image classification.
	Module 5 (Any Two)
	10. Design and implement LSTM model for handwriting recognition, speech recognition, machine translation, speech activity detection, robot control, video games, time series forecasting etc. 11. Design and implement GRU for any real life applications, chat bots etc. 12. Design and implement RNN for classification of temporal data , sequence to sequence data modelling etc.

Textbooks:	
1	Ian Goodfellow, Yoshua Bengio, Aaron Courville. ―Deep Learning‖, MIT Press Ltd, 2016
2	Li Deng and Dong Yu, ―Deep Learning Methods and Applications‖, Publishers Inc.
3	Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill.
4	JM Zurada ―Introduction to Artificial Neural Systems‖, Jaico Publishing House
5	M. J. Kochenderfer, Tim A. Wheeler. ―Algorithms for Optimization‖, MIT Press.
References:	
1	Deep Learning from Scratch: Building with Python from First Principles- Seth Weidman by O`Reilley
2	François Chollet. ―Deep learning with Python ―(Vol. 361). 2018 New York: Manning.
3	Douwe Osinga. ―Deep Learning Cookbook‖, O'REILLY, SPD Publishers, Delhi.
4	Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc
5	S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India
	Web References:
1	https://keras.io/
2	https://stanford.edu/~shervine/teaching/cs-230/cheatsheet-recurrent-neural-networks
3	https://keras.io/examples/vision/autoencoder/
4	https://stanford.edu/~shervine/teaching/cs-230/cheatsheet-convolutional-neural-networks

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignment: 05-marks)
Practical and Oral exam	
	Oral examination based on the entire syllabus of CSC:701

Course Code	Course Name	Credits
CSL702	Big Data Analytics Lab	1

Prerequisite: Java/Python	
Lab Objectives:	
1	To provide an overview of an exciting growing field of big data analytics.
2	To introduce programming skills to build simple solutions using big data technologies such as MapReduce and scripting for NoSQL, and the ability to write parallel algorithms for multiprocessor execution.
3	To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.
4	To enable students to have skills that will help them to solve complex real-world problems in decision support.
Lab Outcomes:	
1	Understand the key issues in big data management and its associated applications for business decisions and strategy.
2	Develop problem solving and critical thinking skills in fundamental enabling techniques like Hadoop, Map reduce and NoSQL in big data analytics.
3	Collect, manage, store, query and analyze various forms of Big Data.
4	Interpret business models and scientific computing paradigms, and apply software tools for big data analytics.
5	Adapt adequate perspectives of big data analytics in various applications like recommender systems, social media applications etc.
6	Solve Complex real world problems in various applications like recommender systems, social media applications, health and medical systems, etc.

Suggested Experiments:

Sr. No.	Name of the Experiment
1	Hadoop HDFS Practical: -HDFS Basics, Hadoop Ecosystem Tools Overview. -Installing Hadoop. -Copying File to Hadoop. -Copy from Hadoop File system and deleting file. -Moving and displaying files in HDFS. -Programming exercises on Hadoop.
2	Use of Sqoop tool to transfer data between Hadoop and relational database servers. a. Sqoop - Installation. b. To execute basic commands of Hadoop eco system component Sqoop.
3	To install and configure MongoDB/ Cassandra/ HBase/ Hypertable to execute NoSQL commands.
4	Experiment on Hadoop Map-Reduce / PySpark: -Implementing simple algorithms in Map-Reduce: Matrix multiplication, Aggregates, Joins, Sorting, Searching, etc.
5	Create HIVE Database and Descriptive analytics-basic statistics, visualization using Hive/PIG/R.
6	Write a program to implement word count programs using MapReduce.
7	Implementing DGIM algorithm using any Programming Language/ Implement Bloom Filter using any programming language.
8	Implementing any one Clustering algorithm (K-Means/CURE) using Map-Reduce.
9	Streaming data analysis – use flume for data capture, HIVE/PYSpark for analysis of twitter data, chat data, weblog analysis etc.
10	Implement PageRank using Map-Reduce.
11	Implement predictive Analytics techniques (regression / time series, etc.) using R/ Scilab/ Tableau/ Rapid miner.

Useful Links	
1	https://nptel.ac.in/courses/117/102/117102062/
2	https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=305
3	https://nptel.ac.in/courses/106/106/106106167/

Term Work:	
1	Term work should consist of 10 experiments
2	Journal must include at least 2 assignments based on Theory and Practical's
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam:	
	Oral examination based on the entire syllabus of CSC702 and CSL702

Course Code:	Course Title	Credit
CSDOL7011	Natural Language Processing Lab	1

Prerequisite: Java/Python	
Lab Objectives:	
1	To understand the key concepts of NLP.
2	To learn various phases of NLP
3	To design and implement various language models and POS tagging techniques
4	To understand various NLP Algorithms
5	To learn NLP applications such as Information Extraction, Sentiment Analysis, Question answering, Machine translation etc.
6	To design and implement applications based on natural language processing
Lab Outcomes:	
1	Apply various text processing techniques
2	Design language model for word level analysis
3	Design, implement and analyze NLP algorithms
4	Realize semantics of English language for text processing
5	To apply NLP techniques to design real world NLP applications such as machine translation, sentiment analysis, text summarization, information extraction, Question Answering system etc.
6	Implement proper experimental methodology for training and evaluating empirical NLP systems

Suggested Experiments:

Sr. No.	Name of the Experiment
1	Study various applications of NLP and Formulate the Problem Statement for Mini Project based on chosen real world NLP applications: [Machine Translation, Text Categorization, Text summarization, Chat Bot, Plagiarism, Spelling & Grammar Checkers, Sentiment / Opinion analysis, Question answering, Personal Assistant, Tutoring Systems, etc.]

2	Apply various text preprocessing techniques for any given text: Tokenization and Filtration & Script Validation
3	Apply various other text preprocessing techniques for any given text: Stop Word Removal, Lemmatization / Stemming
4	Perform morphological analysis and word generation for any given text
5	Implement N-Gram model for the given text input
6	Study the different POS taggers and Perform POS tagging on the given text
7	Perform chunking by analyzing the importance of selecting proper features for training a model and size of training
8	Implement Named Entity Recognizer for the given text input
9	Implement Text Similarity Recognizer for the chosen text documents
10	Implement word sense disambiguation using LSTM/GRU
11	Exploratory data analysis of a given text (Word Cloud)
12	Mini Project Report: For any one chosen real world NLP application
13	Implementation and Presentation of Mini Project

Useful Links	
1	https://nlp-iiith.vlabs.ac.in/List%20of%20experiments.html
2	https://onlinecourses.nptel.ac.in/noc21_cs102/preview
3	https://onlinecourses.nptel.ac.in/noc20_cs87/preview
4	https://nptel.ac.in/courses/106105158

Term Work:	
1	Term work should consist of 08 experiments and mini project
2	Journal must include at least 2 assignments based on Theory and Practical's

3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Course Code:	Course Title	Credit
CSDOL7012	AI for Healthcare Lab	1

Prerequisites: Python	
Lab Objective	
1	To Collect, clean, integrate, and transform healthcare data for a specific disease.
2	To Perform exploratory data analysis on healthcare data.
3	To Develop AI models for medical diagnosis using MRI/X-ray data.
4	To Build AI models for medical prognosis.
5	Extract entities from medical reports using natural language processing.
6	To Predict disease risk using patient data
Lab Outcomes:	
After successful completion of the course, the student will be able to:	
1	Understand computational models of AI ,
2	Develop healthcare applications using appropriate computational tools.
3	Apply appropriate models to solve specific healthcare problems.
4	Analyze and justify the performance of specific models as applied to healthcare problems.
5	Design and implement AI based healthcare applications.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Collect, Clean, Integrate and Transform Healthcare Data based on specific disease.
2	Perform Exploratory data analysis of Healthcare Data.
3	AI for medical diagnosis based on MRI/X-ray data.
4	AI for medical prognosis .
5	Natural language Entity Extraction from medical reports.
6	Predict disease risk from Patient data.
7	Medical Reviews Analysis from social media data.
8	Explainable AI in healthcare for model interpretation.
9	Mini Project-Design and implement innovative web/mobile based AI application using Healthcare Data. (this needs to be implemented in group of 3-4 students)
10	Documentation and Presentation of Mini Project.

Textbooks:	
1	Arjun Panesar, "Machine Learning and AI for Healthcare", A Press.

2	Arvin Agah, "Medical applications of Artificial Systems ", CRC Press

References:	
1	Erik R. Ranschaert Sergey Morozov Paul R. Algra, “Artificial Intelligence in medical Imaging- Opportunities, Applications and Risks”, Springer
2	Sergio Consoli Diego Reforgiato Recupero Milan Petković,“Data Science for Healthcare-Methodologies and Applications”, Springer
3	Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, “Emerging technologies for health and medicine”, Wiley.
4	Ton J. Cleophas • Aeilko H. Zwinderman, “Machine Learning in Medicine- Complete Overview”, Springer
Useful Links	
1	https://www.coursera.org/learn/introduction-tensorflow?specialization=tensorflow-in-practice
2	https://www.coursera.org/learn/convolutional-neural-networks-tensorflow?specialization=tensorflo w- in-practice
3	https://datarade.ai/data-categories/electronic-health-record-ehr-data
4	https://www.cms.gov/Medicare/E-Health/EHealthRecords
5	https://www.coursera.org/learn/tensorflow-sequences-time-series-and-prediction?specialization=te nsorflow-in-practice

Term Work:	
1	Term work should consist of 8 experiments and a Mini Project.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks (Experiments: 10-Marks, Mini Project-10 Marks, Attendance Theory & Practical: 05 marks)

Course Code:	Course Title	Credit
CSDOL7013	Neural Networks and Fuzzy Systems Lab	1

Prerequisite: C/C++/Java/MATLAB	
Lab Objectives:	
1	Articulate basic knowledge of fuzzy set theory through programing.
2	To design Associative Memory Networks.
3	To apply Unsupervised learning towards Networks design.
4	To demonstrate Special networks and its applications in soft computing.
5	To implement Hybrid computing systems.
Lab Outcomes: At the end of the course, the students will be able to	
1	Implement Fuzzy operations and functions towards Fuzzy-rule creations.
2	Build and training Associative Memory Network.
3	Build Unsupervised learning based networks .
4	Design and implement architecture of Special Networks
5	Implement Neuro-Fuzzy hybrid computing applications.

Suggested Experiments:

Sr. No.	Name of the Experiment
1	Demonstrate Union and intersection of two Fuzzy Sets.
2	Demonstrate difference between two Fuzzy Sets.
3	Implement Fuzzy membership functions.
4	Implement Fuzzy Inference system (FIS).
5	Implement any De-fuzzification of membership method.
6	Implement Bidirectional Associative Memory(BAM) Network
7	Implement Radial basis function network.
8	Implement Basic Neural Network learning rules.
9	Implement any Unsupervised Learning algorithm.

10	Implement Kohonen Self- Organizing Feature Maps
11	Implement a Probabilistic Neural Network.
12	Implement any Ensemble neural model.
13	Design any one Neuro-Fuzzy system.

Useful Links	
1	https://onlinecourses.nptel.ac.in/noc21_ge07/preview
2	http://www.nitttrc.edu.in/nptel/courses/video/127105006/L25.html
3	https://archive.nptel.ac.in/courses/108/104/108104157/

Term Work:	
1	Term work should consist of 08 experiments, 1 case study.
2	Journal must include at least 2 assignments based on Theory and Practical's.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Course Code:	Course Title	Credit
CSDOL7021	User Experience Design with VR Lab	1

Prerequisite: Computer Graphics, Python	
Lab Objectives:	
1	To perform installation of Unity
2	To explore working of VR Gadget
3	To develop scene VR application
4	To track objects in virtual environment
Lab Outcomes:	
1	Setup VR development environment
2	Use HTC Vive/ Google Cardboard/ Google Daydream and Samsung gear VR.
3	Develop VR scene and place object
4	Identify, examine and develop software that reflects fundamental techniques for the design and deployment of VR experiences

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Installation of Unity and Visual Studio, setting up Unity for VR development, understanding documentation of the same.
2	Demonstration of the working of HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.
3	Develop a scene in Unity that includes: i. a cube, plane and sphere, apply transformations on the 3 game objects. ii. add a video and audio source
4	Develop a scene in Unity that includes a cube, plane and sphere. Create a new material and texture separately for three Game objects. Change the colour, material and texture of

	each Game object separately in the scene. Write a C# program in visual studio to change the colour and material/texture of the game objects dynamically on button click
5	Develop a scene in Unity that includes a sphere and plane . Apply Rigid body component, material and Box collider to the game Objects. Write a C# program to grab and throw the sphere using vr controller.
6	Develop a simple UI(User interface) menu with images, canvas, sprites and button. Write a C# program to interact with UI menu through VR trigger button such that on each successful trigger interaction display a score on scene .
7	Create an immersive environment (living room/ battlefield/ tennis court) with only static game objects. 3D game objects can be created using Blender or use available 3D models
8	Include animation and interaction in the immersive environment created in Assignment 7.
9	Case Study/Mini Project: Create a virtual environment for any use case. The application must include at least 4 scenes which can be changed dynamically, a good UI, animation and interaction with game objects. (e.g. VR application to visit a zoo)
10	Presentation of Mini Project

Useful Links	
1	https://nptel.ac.in/courses/106106138
2	https://nptel.ac.in/courses/121106013
3	https://www.coursera.org/learn/develop-augmented-virtual-mixed-extended-reality-applications-webxr-unity-unreal
4	https://tih.iitr.ac.in/AR-VR.html

Term Work:	
1	Term work should consist of 08 experiments and mini project
2	Journal must include at least 2 assignments based on Theory and Practical's

3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Course Code:	Course Title	Credit
CSDOL7022	Blockchain Technologies Lab	1

Prerequisite: Java, Python, JavaScript.	
Lab Objectives:	
1	To develop and deploy smart contracts on local Blockchain.
2	To deploy the smart contract on test networks.
3	To deploy and publish smart contracts on Ethereum test network.
4	To design and develop crypto currency.
5	To deploy chain code on permissioned Blockchain.
6	To design and develop a Full-fledged DApp using Ethereum/Hyperledger.
Lab Outcomes:	
1	Develop and test smart contract on local Blockchain.
2	Develop and test smart contract on Ethereum test networks.
3	Write and deploy smart contract using Remix IDE and Metamask.
4	Design and develop Cryptocurrency.
5	Write and deploy chain code in Hyperledger Fabric.
6	Develop and test a Full-fledged DApp using Ethereum/Hyperledger.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Local Blockchain: Introduction to Truffle, establishing local Blockchain using Truffle **a)** Cryptography in Blockchain and Merkle root tree hash
2	**Smart contracts and Chain code:** Solidity programming language, chain code (Java/JavaScript/Go), deployment on Truffle local a) Creating Smart Contract using Solidity b) Embedding wallet and transaction using Solidity

3	**Deployment and publishing smart contracts on Ethereum test network:** Ethereum Test networks (Ropsten/Gorelli/Rinkeby), deployment on test networks, Web3.js/Web3.py for interaction with Ethereum smart contract a) Blockchain platform ethereum using Geth. b) Blockchain platform Ganache
4	**Remix IDE and Metamask:** Smart contract development and deployment using Metamask and Remix. Design and develop Crypto currency
5	**Chain code deployment in Hyperledger Fabric:** Chain code deployment in Hyperledger fabric Mini project: Study required front end tools
6	Case Study on Hyperledger
7	Case Study on Other Blockchain platforms.
8	Creating a blockchain Application
9	**Mini-project on Design and Development of a DApps using Ethereum/Hyperledger Fabric**: Implementation of Mini Project, 1. Design, configure and testing of mini project 2. Report submission as per guidelines 3. Implementation and Presentation of Mini Projects

Text Books:

1. Ethereum Smart Contract Development, Mayukh Mukhopadhyay, Packt publication.
2. Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Blockchain, Ritesh Modi, Packt publication.
3. Hands-on Smart Contract Development with Hyperledger Fabric V2, Matt Zand, Xun Wu and Mark Anthony Morris, O'Reilly.

Reference Books:

1. Mastering Blockchain, Imran Bashir, Packt Publishing
2. Introducing Ethereum and Solidity, Chris Dannen, APress.
3. Hands-on Blockchain with Hyperledger, Nitin Gaur, Packt Publishing.

Mini project:

1. Students should carry out mini-project in a group of three/four students with a subject In-charge
2. The group should meet with the concerned faculty during laboratory hours and the

progress of work discussed must be documented.

3. Each group should perform a detailed literature survey and formulate a problem statement.
4. Each group will identify the hardware and software requirement for their defined mini project problem statement.
5. Design, develop and test their smart contract/chain code.
6. Each group may present their work in various project competitions and paper presentations

Documentation of the Mini Project

The Mini Project Report can be made on following lines:

1. Abstract
2. Contents
3. List of figures and tables
4. Chapter-1 (Introduction, Literature survey, Problem definition, Objectives, Proposed Solution, Technology/platform used)
5. Chapter-2 (System design/Block diagram, Flow chart, Software requirements, cost estimation)
6. Chapter-3 (Implementation snapshots/figures with explanation, code, future directions)
7. Chapter-4 (Conclusion)
8. References

Useful Links	
1	https://trufflesuite.com/
2	https://metamask.io/
3	https://remix.ethereum.org/
4	https://www.hyperledger.org/use/fabric

Term Work:	
1	Term work should consist of 08 experiments and mini project
2	Journal must include at least 2 assignments based on Theory and Practical's
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Course Code:	Course Title	Credit
CSDOL7023	Game Theory for Data Science LAB	1

Prerequisite: Probability, Algebra

Lab Objectives:	
1	To understand fundamental game theory concepts.
2	To apply game theory to real-world data science scenarios.
3	To analyze Nash equilibria in different types of games.
4	To investigate mixed strategies and their implications.
5	To learn game theory algorithms and computational tools.
6	To explore applications of game theory in data science.

Lab Outcomes: Learner will be able to	
1	Gain a solid understanding of fundamental game theory concepts.
2	Develop the ability to apply game theory principles to real-world data science problems.
3	Analyze and identify Nash equilibria in various game scenarios.
4	Comprehend the implications and applications of mixed strategies in game theory.
5	Acquire practical skills in utilizing game theory algorithms and computational tools.
6	Explore and appreciate the wide range of applications of game theory in data science.

Suggested Experiment	
1.	Prisoners dilemma
2.	Pure Strategy Nash Equilibrium
3.	Extensive Form – Graphs and Trees, Game Trees
4.	Strategic Form – Elimination of dominant strategy
5.	Minimax theorem, minimax strategies
6.	Perfect information games: trees, players assigned to nodes, payoffs, backward Induction, subgame perfect equilibrium,
7.	Imperfect-information games – Mixed Strategy Nash Equilibrium – Finding mixed-strategy Nash equilibria for zero sum games, mixed versus behavioral strategies.
8.	Repeated Games
9.	Bayesian Nash equilibrium
10	Implementation of any game for example Tic Tac To , coloring triangle , water jug , 8 queen , 8 puzzle etc (this should be done in group of 3-4)

Textbooks:	
1	An Introduction to Game Theory by Martin J. Osborne
2	M. J. Osborne, An Introduction to Game Theory. Oxford University Press, 2004.

References:	
1	M. Machler, E. Solan, S. Zamir, Game Theory, Cambridge University Press, 2013.
2	N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani (Editors), Algorithmic Game Theory. Cambridge University Press, 2007.
3	A.Dixit and S. Skeath, Games of Strategy, Second Edition. W W Norton & Co Inc, 2004.
4	YoavShoham, Kevin Leyton-Brown, Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge University Press 2008.
5	Zhu Han, DusitNiyato, WalidSaad, TamerBasar and Are Hjorungnes, "Game Theory in Wireless and Communication Networks", Cambridge University Press, 2012.
6	Y.Narahari, "Game Theory and Mechanism Design", IISC Press, World Scientific.

Digital References:

1. https://nptel.ac.in/courses/110104063
2. https://onlinecourses.nptel.ac.in/noc19_ge32/preview

Term Work:

1. Term work should consist of 10 experiments.
2. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4. Total 25 Marks: Experiments- 15-marks, Attendance Theory & Practical: 05-marks, Assignment: 05-marks.

Course Code:	Course Title	Credit
CSP701	Major Project 1	3

Course Objectives:	
1	To acquaint with the process of identifying the needs and converting it into the problem.
2	To familiarize the process of solving the problem in a group.
3	To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4	To inculcate the process of self-learning and research.
Course Outcomes:	
1	Identify problems based on societal /research needs.
2	Apply Knowledge and skill to solve societal problems in a group
3	Draw the proper inferences from available results through theoretical/ experimental/simulations
4	Analyse the impact of solutions in societal and environmental context for sustainable development.
5	Demonstrate capabilities of self-learning in a group, which leads to life long learning.
6	Demonstrate project management principles during project work.

Guidelines:

1. Project Topic Selection and Allocation:

- Project topic selection Process to be defined and followed:
  - Project orientation can be given at the end of sixth semester.
  - Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
  - Student‘s should be recommended to refer papers from reputed conferences/journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
  - Dataset selected for the project should be large and realtime
  - Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer Digital India portal, SIH portal or any other hackathon portal forproblem selection.

- Topics can be finalized with respect to following criterion:
  - **Topic Selection**: The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.

- **Technology Used:** Use of latest technology or modern tools can be encouraged. AI, ML, DL, NNFS, NLP based algorithms can be implemented
- Students should not repeat work done previously (work done in the last three years).
- Project work must be carried out by the group of at least 3 students and maximum 4.
- The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
- The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
- Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.
- Guide allocation should be done and students have to submit weekly progress report to the internal guide.
- Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.
- In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels

2. Project Report Format:

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai.

A project report should preferably contain following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective
- Proposed System
- Analysis/Framework/ Algorithm
- Design details
- Methodology (your approach to solve the problem) Proposed System
- Experimental Set up
- Details of Database or details about input to systems or selected data
- Performance Evaluation Parameters (for Validation)
- Software and Hardware Setup
- Implementation Plan for Next Semester
- Timeline Chart for Term1 and Term-II (Project Management tools can be used.)
- References

Desirable

Students can be asked to undergo some Certification course (for the technical skill set thatwill be useful and applicable for projects.)