Employability/ Entrepreneurship/ Skill development

Sl No	Course Code	Course name	Activities with direct bearing on Employability/ Entrepreneurship/ Skill development	Year of Introduction
1.	CS823	Blockchain Technology	Understanding of Blockchain implementation, smart contracts and blockchain platforms like Ethereum, Hyperledger etc.	2020
2.	CS824	Advanced Digital Image Processing	Students will acquire ability to apply image enhancement techniques in spatial and frequency domain to devise algorithms or mathematical models for real time image enhancement and restoration problems Acquire knowledge about various object representation, description and recognition techniques to carry out automatic image understanding	2020
3.	CS825	Fundamentals of Computational Biology	Acquire knowledge about various standardized tools and programming languages applicable in system biology application domains	2020
4.	CS826	Advanced Data Mining	Students will learn about various techniques for mining information from data and will be able to apply the knowledge for processing real world data.	2020
5.	CS827	Foundation course for Oceanography	Acquire knowledge about probability, different probability distributions and thus able to fit a data into particular patterns.	2020
6.	CS828	Mathematical Foundation for Cyber Security	Students will learn the mathematical principles and functions that form the foundation of cryptography. Students will acquire the knowledge of applying the properties probability distributions in Cyber security applications.	2020
7.	CS829	Deep Learning	Students will learn to develop intelligent systems that learn from complex and/or large-scale datasets	2020
8.	CS830	Fundamentals of Network Biology :Theory And Applications	Acquire knowledge about designing of various algorithms to solve large real-world network problems, devise models of network structure to predict the behavior of networked systems	2020

Programme Outcomes:

PO1. Computational knowledge: Apply the knowledge of mathematics, science, domain knowledge to the solution of complex problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex research problems reaching substantiated conclusions using first principles of mathematics, natural sciences, engineering sciences and domain knowledge.

PO3. Design/development of solutions: Design solutions for complex research problems and design system components or processes that meet the specified needs with appropriate consideration.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern computational tools including prediction and modeling to complex research activities with an understanding of the limitations.

PO6. The researcher and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities.

PO7. Environment and sustainability: Understand the impact of physical processes in societal and environmental contexts, and demonstrate the knowledge, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex scientific activities with the research community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and Research: Demonstrate knowledge and understanding of the scientific and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Code	Course name	L-T-P-Credits	Year of Introduction
CS823	**Blockchain Technology**	**3 0 0 3**	**2020**

Course Objectives

This course aims to provide conceptual understanding of the function of Blockchains as a method of securing distributed ledgers, how consensus on their contents is achieved, and the new applications that they enable. It covers the technological underpinnings of blockchain operations as distributed data structures and decision-making systems, their functionality and different architecture types. It provides a critical evaluation of existing "smart contract" capabilities and platforms, and examines their future directions, opportunities, risks and challenges.

Course Outcome:

CO1	Understanding Blockchain data structure, hash chain mechanisms and the working of distributed databases. It also gives an overview about blockchain architecture. Be familiar with hash functions and asymmetric key cryptography and private key cryptography. Study about Blockchain storage, ledgers and chaining blocks
CO2	Understanding crypto primitives-Bitcoin basics-Consensus and multi-part agreements. Also familiarize different Consensus algorithms like PoW, PoS, Byzantine Fault Tolerance etc.
CO3	Understanding Blockchain implementation, smart contracts and blockchain platforms like Ethereum, Hyperledger etc
CO4	Be familiar with IPFS protocol blockchain and various network models and timing assumptions, smart contract programming
CO5	Understanding Blockchain for enterprise- Real-World Applications- Blockchain use cases – opportunities, risks and challenges.

Course Content

Unit-1

Introduction to Blockchain Architecture--Blockchain components and concepts –Conceptualization- Hash chain - Asymmetric-Key Cryptography - Private key Cryptography-Hash Functions- Ledgers, Blocks, Chaining Blocks

Unit-2

Basic crypto primitives-Bitcoin Basics-Distributed Consensus-Consensus in Bitcoin- permissioned blockchain- Protocols, Proof of Work, Proof of Stake, Delegated Proof of Stake, Proof of Elapsed Time, Deposit based consensus, Proof of importance- Federated consensus or Federated Byzantine consensus, Reputation-based mechanisms, Practical Byzantine Fault Tolerance.

Unit-3

Blockchain implementation, Forking - Soft Fork, Hard Forks, Cryptographic Changes and Forks, Blockchain Platforms – Cryptocurrencies (Bitcoin, Litecoin, Ethereum, Ripple), Hyperledger, Ethereum. Blockchain - Outside of Currencies

Unit-4

IPFS protocol and Blockchain, Blockchain Concurrency and scalability, Network models and timing assumptions. Smart contract programming

Unit-5

Blockchain for enterprise- Real-World Applications- Scaling blockchain to other applications-Future of Blockchains-Blockchain use cases -opportunities, risks and challenges.

TEXT BOOKS/REFERENCES:

1. Abhijit Das and Veni Madhavan C. E., Public-Key Cryptography: Theory and Practice, Pearson Education India, 2009.
2. Melanie Swan, Blockchain - Blueprint for a new economy, O’Reilly Media, Inc., 2015.
3. Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction, Princeton University
4. Roger Wattenhofer, CreateSpace, The Science of the Blockchain, Independent Publishing Platform, 2016
5. Imran Bashir, Mastering Blockchain, 2017.
6. Andreas M. Antonopoulos, Mastering Bitcoin - Programming the Open Blockchain, O’Reilly Media, Inc., 2017
7. Alex Leverington, Ethereum Programming, Packt Publishing Limited, 2017.
8. Draft NISTIR 8202, Blockchain Technology Overview - NIST CSRC, 2018.

CO – PO Affinity Map

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO1	3	2	2	1	1	-	-	-	-	-	-	-	-	-	-
CO2	2	1	1	3	1	-	-	-	-	-	-	-	-	-	-
CO3	1	1	3	3	3	-	-	-	-	-	-	-	-	-	-
CO4	2	1	3	1	3	-	-	-	-	-	-	-	-	-	-
CO5	1	2	3	1	2	-	-	-	-	-	-	-	-	-	-

Course Code	Course name	L-T-P-Credits	Year of Introduction
CS824	**Advanced Digital Image Processing**	**3 0 1 4**	**2020**

Course Objectives

The aim of this course is to inculcate a comprehensive knowledge about various Digital Image processing/ recognition techniques and its applications.

Course Outcome

CO1	Understanding of the fundamental concepts of a digital image processing and various image transforms.
CO2	Ability to apply image enhancement techniques in spatial and frequency domain to devise algorithms or mathematical models for real time image enhancement and restoration problems.
CO3	Understanding of various edge detection techniques and the ability to implement segmentation algorithms used to detect and extract the region of interest from images.
CO4	Interpretation and use of feature extraction and image representation techniques
CO5	Acquire knowledge about various object representation, description and recognition techniques to carry out automatic image understanding.

Course Content

UNIT-I
Introduction, Image acquisition process, Sampling & quantization, basic relationships between pixels-neighbours, adjacency, connectivity, path, regions and boundaries, Image transforms-Unitary Transform and properties, 2D Fourier Transform, 2D FFT, Discrete Fourier Transform (DFT), Properties of DFT, 2D DCT and properties, Walsh-Hadamard Transform, K-L Transform, Principal Component Analysis (PCA), Wavelet transform (Definition, Properties, Mathematical function)

UNIT-II
Image Enhancement: Basic intensity transformation functions, Histogram processing- equalization, specification and modification, Enhancement using arithmetic/ logicl operations, Spatial filtering-smoothing and sharpening filters, Frequency domain filtering- Smoothing and sharpening filters
Image restoration : Image restoration and degradation model, Noise types and their pdfs, mean filters, order statistics filters, adaptive filters, Inverse filtering, Weiner Filter, Tikhonov Regularization, LMMSE filters, constrained least squares filters
UNIT-III
Edge Detection: Mathematical concepts, Operators based on first order derivative (Roberts, Prewitt and Sobel), Laplacian (Second order derivative based edge detection),LOG
Image Segmentation: Thresholding based (Local, Global, Adaptive), Region based (Region split & merge, Region growing), Cluster based (K-means, Fuzz c-means), Contour based (Snakes' method), Graph based segmentation methods

UNIT-IV
Feature extraction: Spatial Features, Amplitude, Transform based features, Fourier Descriptors (FDs), Histogram based statistical features, Based on statistical moments (e.g., mean, variance, kurtosis, etc), Shape/geometry based features & moment based features(Radii, perimeter, area, compactness, max

boundary rectangle, orientation etc.), Texture features (GLCM features, Gabor features, LBP), Color features

Unit V

Object representation, description and recognition:

Boundary representation- Chain codes, Polygon approximations, Signatures, Boundary segments, Skeletons. Boundary description- Shape numbers, Statistical moments

Region representation- Data structures used for representing region, Region description- Topological description, Texture, Moments, Principal components

Object recognition: Patterns & pattern classification, Recognition based on decision theoretic methods, Structural methods.

Programming implementation of image enhancement, restoration, segmentation, feature extraction and image recognition techniques.

References:

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 4th Ed., Pearson, March 2017.
2. Anil K. Jain, “Fundamentals of Digital Image Processing”, Pearson, 1st Ed., 1988.
3. William K. Pratt, “Digital Image Processing: PIKS Scientific Inside”, John Wiley & Sons,4th Ed., 2007.
4. Azriel Rosenfield, Avinash C. Kak, "Digital Picture Processing", Morgan Kaufmann, 2ndEd., 1982.
5. Bernd Jahne, “Digital Image Processing”, Springer, 6th Ed., 2005.
6. Milan Sonka , “Image Processing and Analysis’
7. Relevant research papers

CO – PO Affinity Map

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO1	3	1	1	1	1	-	-	-	-	-	-	-	-	-	-
CO2	2	1	1	3	1	-	-	-	-	-	-	-	-	-	-
CO3	1	1	3	2	1	-	-	-	-	-	-	-	-	-	-
CO4	2	1	3	2	1	1	1	-	-	-	-	-	-	-	-
CO5	1	2	3	1	2	1	1	-	-	-	-	-	-	-	-

Course Code CS825	Course name Fundamentals of Computational Biology	L-T-P-Credits 3 0 1 4	Year of Introduction 2020

Course Objectives

The main goal of this course is to provide students an introduction to different computational problems and key network based algorithms to counter these problems. The course will provide the relevant background in molecular biology , omic data analysis and network medicine that are needed to grasp the concepts introduced in the course. Finally, this course delivers the usability of modern tool usage for omic data analysis.

Course Outcome

CO1	Knowledge of basic molecular biology concepts used in Computational Biology.
CO2	Understanding of the basic public high throughput databases and algorithms used in Computational Biology.
CO3	Ability to integrate various omic approaches for improving the quality of life.
CO4	Ability to view human system through the lens of network medicine.
CO5	Acquire knowledge about various standardized tools and programming languages applicable in system biology application domains.

Course Content

UNIT-I

OVERVIEW OF MOLECULAR BIOLOGY: Cell-Prokaryotic cell and Eukaryotic cell, Cell Structure and Function- cell membrane, cell organelles; Cell Cycle , Cell Signalling and Cell Division; Mitosis & Meiosis; Central Dogma: DNA-RNA-Protein; Biomolecules and its functions: DNA, RNA, amino acids, Protein, miRNA, metabolites etc. ; Cellular Components – Cytoskeleton, Microtubules, Golgi complex

UNIT-II

OMIC DATA ANALYSIS: Biomedical data - acquisition, storage and use, Imaging Systems; Evolution of the genome- Human Genome Project, ENCODE; Overview of Public Data Repositories for: Protein, Gene, Nucleotide sequence, Structural, Interaction network, pathway etc.; Gene Ontology and enrichment analysis, Pathway enrichment analysis; Genomics and Transcriptome Analysis; Functional Genomics.

UNIT-III

ALGORITHMS IN COMPUTATIONAL BIOLOGY: Genetic Algorithm- Basic Concepts, Reproduction, Cross over, Mutation, Fitness Value, Optimization using GAs; Applications of GA in bioinformatics; Hidden Markov Model- Markov processes and Markov Models, Hidden Markov Models. Forward and Backward Algorithms; Application of Machine learning tools viz. Neural network, Bayesian network, Support Vector Machines in bioinformatics.

UNIT-IV

HUMAN SYSTEM AND NETWORK MEDICINE: Diverse perturbations on cellular networks- Perturbations, System Level Networks, Phenotypes etc.; Overview of Interaction Networks- Gene Regulatory Networks, Protein – Protein Interaction Networks, Metabolic Networks; Disease Networks, Network Modules-Hubs, Network Motifs; Tissue or Condition Specific Interactome;

Unit V

COMPUTATIONAL BIOLOGY TOOLS AND STANDARDS: Introduction to Matlab, Biojava, Bioperl etc.; Systems Biology toolbox; SBML; SBGL (Systems Biology Graphical Language); KEGG;PANTHER; Gene Ontology; Tools for systems Biology- Cytoscape, Familiarization with bioinformatics databases: STRING,GEO,NCBI, PDB, UNIPROT, OMIM, DrugBank etc.

References:

1. Becker, W. M., Kleinsmith, L. J., Hardin, J., & Raasch, J. (2003). The world of the cell (Vol. 6).
2. Claverie,J.,M., Notredame,C.(2003).Bioinformatics: A Beginner's Guide. Wiley India Pvt. Limited3.
3. An introduction to bioinformatics algorithms by Neil C. Jones, Pavel Pevzner. MIT Press. 2004
4. Network Medicine: Complex Systems in Human Disease and Therapeutics 1st Edition- By Joseph Loscalzo, Albert-Laszlo Barabasi, And Edwin K. Silverman.
5. Introduction to Computational Biology by Bernhard Haubold, Thomas Wiehe

CO – PO Affinity Map

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
CO2	1	1	2	2	3	-	-	-	-	-	-	-	-	-	-
CO3	1	1	2	1	3	-	-	-	-	-	-	-	-	-	-
CO4	1	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO5	1	2	3	-	-	-	-	-	-	-	-	-	-	-	-

Course Code CS826	Course name Advanced Data Mining	L-T-P-Credits 3 0 1 4	Year of Introduction 2020

Course Objectives

This course focuses on data mining techniques for both structured data which conform to a clearly defined schema, and unstructured data which exist in the form of natural language text. Specific course topics include pattern discovery, clustering, text retrieval, text mining and analytics, and data visualization. The expected outcome is to solve real-world data mining challenges using these concepts.

Course Outcome

CO1	Understanding of basic concepts, tasks, methods, and techniques in data mining.
CO2	Ability to categorize and carefully differentiate between situations for applying different data mining techniques: frequent pattern mining, association, correlation, classification, prediction, cluster, and outlier analysis.
CO3	Ability to evaluate the performance of different data mining algorithms.
CO4	Understand the basic concepts of cluster analysis, study a set of typical clustering methodologies, algorithms, and applications.
CO5	To learn advanced and cutting edge state-of-the-art knowledge and implementation in data mining.

Course Content:

UNIT-I

Data Mining: - Concepts and Applications. Data Preprocessing: - Data Preprocessing Concepts, Data Cleaning, Data Integration, Data Reduction, Data Transformation and Discretization.

UNIT-II

Mining Frequent Patterns, Associations, and Correlations: - Basic Concepts and Methods. Frequent Itemset Mining Methods: - Apriori Algorithm and FP-Growth. Classification Models: Introduction to Classification and Prediction, Issues regarding classification and prediction, Decision Tree- ID3, C4.5, Naive Bayes Classifier,SVM

UNIT-III

Neural Networks: - Back propagation. Support Vector Machines, K Nearest Neighbor Classifier. Accuracy and Error Measures evaluation. Prediction: -Linear Regression and Non-Linear Regression.

UNIT-IV

Cluster Analysis: Introduction, Concepts, Types of data in cluster analysis, Categorization of clustering methods. Partitioning method: K-Means and K-Medoid Clustering. Hierarchical Clustering method: BIRCH. Density-Based Clustering –DBSCAN and OPTICS.

Unit V

Advanced Data Mining Techniques: Introduction, Web Mining- Web Content Mining, Web Structure Mining, Web Usage Mining. Text Mining.

References:
1. Dunham M H, “Data Mining: Introductory and Advanced Topics”, Pearson Education, New Delhi, 2003.
2. Jaiwei Han and Micheline Kamber, “Data Mining Concepts and Techniques”, Elsevier, 2006.
3. Mehmed Kantardzic, “Data Mining Concepts, Methods and Algorithms”, John Wiley and Sons, USA, 2003.
4. Pang-Ning Tan and Michael Steinbach, “Introduction to Data Mining”, Addison Wesley, 2006.

CO – PO Affinity Map

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	3	2	2	2	2	-	-	-	-	-	-	-	-	-
CO3	1	2	3	2	1	1	-	-	-	-	-	-	-	-	-
CO4	2	1	3	1	1	1	-	-	-	-	-	-	-	-	-
CO5	2	2	3	3	2	-	-	-	-	-	-	-	-	-	-

Course Code	Course name	L-T-P-Credits	Year of Introduction
CS827	**Foundation course for Oceanography**	**4-0-0-4**	**2020**

Course Objectives

This course focuses on providing complete awareness on the dynamics associated with oceans, causes and effects of various oceanic processes. It describes the identification and application of computational and mathematical techniques to real time models.

Course Outcome

CO1	To enable students to learn the fundamentals of physics of ocean, some basic properties and systems of ocean.
CO2	To understand various dominant forces in ocean and have an insight into the dynamics of flow of water and transports taking place inside the ocean.
CO3	To understand machine learning techniques to devise algorithms or mathematical models for real time data.
CO4	Compute limits, derivatives, and integrals; analyze functions using them and recognize the appropriate tools of calculus to solve applied problems.
CO5	Acquire knowledge about probability, different probability distributions and thus able to fit a data into particular patterns.

Course Content:

Unit 1 :

Physics of the ocean, Bathymetric features, measuring the depth of oceans, Sound in the ocean, Atmospheric wind systems, Oceanic heat budget, Physical properties of water, temperature, salinity and density, Oceanic mixed layer, Light in the ocean.

Unit 2:

Dominant forces for ocean dynamics, Types of flow in the ocean, Mixing in the ocean, Response of upper ocean to winds, Ekman layers and transports, Ekman pumping, Wind driven circulations in ocean, deep circulations in the ocean, thermohaline circulations, Equatorial processes: El-Nino.

Unit 3:

Introduction to Machine learning, Types of machine learning, Regression, Clustering, Support Vector Machines, SMO algorithm, Dimensionality reduction PCA, Clustering, Graphical model structure learning, Generative models for discrete data: Bayesian concept learning Likelihood, Posterior predictive distribution, The beta-binomial model, Naive Bayes classifiers.

Unit 4:

Differential Calculus: Derivative as a rate measure, rate of change, velocity, acceleration, derivative as a measure of slope, tangent, normal and angle between curves. Maxima and Minima, Mean value theorem, Rolle’s Theorem, Lagrange Mean Value Theorem, Taylor’s and Maclaurin’s series, L’ Hôpital’s Rule, stationary points, increasing, decreasing, maxima, minima, concavity, convexity and points of inflection.

Unit 5:

Measures of dispersion: Mean, median and mode, variance and standard deviation of ungrouped/grouped data. Probability, conditional probability, independent events, total probability and Baye's theorem. Random Variable, Probability density function, distribution function, mathematical expectation, variance, Discrete Distributions − Binomial, Poisson, Continuous Distribution − Normal distribution.

References:

1. Introduction to Physical Oceanography – Robert H Stewart.
2. Oceanography- Savindra Singh.
3. An introduction to Machine Learning – Miroslav Kubat.
4. Machine Learning: A probabilistic perspective – Kevin P Murphy.
5. Thomas’ Calculus – George B Thomas.
6. Introduction to Probability and Statistics for Engineers and Scientists – Sheldon M Ross.

CO – PO Affinity Map

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO1	2	1	1	1	-	1	1	-	-	-	-	-	-	-	-
CO2	2	2	1	2	1	-	-	-	-	-	-	-	-	-	-
CO3	3	2	2	2	3	-	-	-	-	-	-	-	-	-	-
CO4	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-
CO5	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-

Course Code CS828	Course name Mathematical Foundation for Cyber Security	L-T-P-Credits 3 1 0 4	Year of Introduction 2020

Course Objectives: The goal of this course is for students to be introduced to the basic mathematical and programming tools used in modern security research and practices. These concepts will help them to develop security model and analyse them before being used in many commercial, industrial as well as web application.

Course Outcome

CO1	Understand basic concepts of graph theory and its applications
CO2	Effectively express the concepts and results of Number Theory and how it can be applied in cryptography
CO3	Understand fundamental abstract algebra principles used in classical and modern cryptosystems
CO4	To provide the concept of probability and conditional probability

Course Content

Graph Theory: Euler graphs, Hamiltonian paths and circuits, planar graphs, trees, rooted and binary trees, distance and centres in a tree, fundamental circuits and cut sets, graph colorings and applications, chromatic number, chromatic partitioning, chromatic polynomial, matching, vector spaces of a graph.

Analytic Number Theory: Euclid's lemma, Euclidean algorithm, basic properties of congruences, residue classes and complete residue systems, Euler-Fermat theorem, Lagrange's theorem and its applications, Chinese remainder theorem, primitive roots. Algebra: groups, cyclic groups, rings, fields, finite fields and their applications to cryptography.

Linear Algebra: vector spaces and subspaces, linear independence, basis and dimensions, linear transformations and applications.

Probability and Statistics: introduction to probability concepts, random variables, probability distributions (continuous and discrete), Bayesian approach to distributions, mean and variance of a distribution, joint probability distributions, theory of estimation. Bayesian methods of estimation. Random Processes: general concepts, power spectrum, discrete-time processes, random walks and other applications.

TEXTBOOKS / REFERENCES:

1. R.P.Grimaldi, "*Discrete and Combinatorial Mathematics*", Fifth edition, Pearson Education, 2007.
2. K. H. Rosen, "*Discrete Mathematics and its applications*", Seventh Edition, Tata MCGraw-Hill Publishing company limited, New Delhi, 2007.
3. H. Anton, "*Elementary Linear Algebra*", John Wiley & Sons, 2010.
4. N. Deo, "*Graph theory with applications to Engineering and Computer Science"*, Prentice Hall of India, New Delhi, 1974.
5. T. M. Apostol, "*Introduction to Analytic Number Theory"*, Springer, 1976.
6. Douglas C. Montgomery and George C. Runger, "*Applied Statistics and Probability forEngineers"*, third Edition, John Wiley & Sons Inc., 2003.
7. A. Papoulis and U. Pillai, Probability, "*Random Variables and Stochastic Processes"*, Fourth Edition, McGraw Hill, 2002.
8. Ronald E. Walpole, Raymond H Myres, Sharon.L.Myres and Kying Ye, "*Probability andStatistics for Engineers and Scientists"*, Seventh Edition, Pearson Education, 2002.

CO – PO Affinity Map															
PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	PS0 1	PSO 2	PSO 3
CO1	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	1	1	1	-	-	-	-	-	-	-	-	-	-	-
CO3	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-
CO4	2	1	3	-	-	-	-	-	-	-	-	-	-	-	-

Course Code CS829	Course name DEEP LEARNING	L-T-P-Credits 3 0 1 4	Year of Introduction 2020

Course Objectives:

This course aims to present the mathematical, statistical and computational challenges of building stable representations for high-dimensional data. Various deep neural network architectures, practical aspects, formulation and implementation of solutions to real-life problems using deep learning models will be covered in this course.

Course Outcome:

CO1	Understanding of the motivation for deep learning
CO2	Practical understanding of machine learning methods based on learning data
CO3	Development of intelligent systems that learn from complex and/or large-scale datasets
CO4	Understanding of various deep learning architectures and its application to practical problems

Course Content

Biological Neuron, Idea of computational units, Binary Classification, Logistic Regression, Gradient Descent, Derivatives, Computation graph, Vectorization, Vectorizing logistic regression – Shallow neural networks: Activation functions, non-linear activation functions, Backpropagation, Data classification with a hidden layer

Deep Neural Networks: Deep L-layer neural network, Forward and Backward propagation, Deep representations, Parameters vs Hyperparameters, Building a Deep Neural Network (Application) - Supervised Learning with Neural Networks

Practical aspects of Deep Learning: Train/Dev/Test sets, Bias/variance, Overfitting and regularization, Regularization methods (L1 and L2 regularization, dropout, drop connect, batch normalization, early stopping, data augmentation), Linear models and optimization, Vanishing/exploding gradients, Gradient checking-logistic Regression

Convolution Neural Networks, RNN and Backpropagation –Convolutions and Pooling – Optimization algorithms: Mini-batch gradient descent, exponentially weighted averages, RMSprop, Learning rate decay, problem of local optima, Batch norm – Parameter tuning process.

Neural Network Architectures – Recurrent Neural Networks, Adversarial NN, Spectral CNN, Self-Organizing Maps, Restricted Boltzmann Machines, Long Short-Term Memory Networks
(LSTM) and Deep Reinforcement Learning.
Overview of AlexNet, VGG Net, Google Net, ResNet, Yolo, GAN etc. Transfer Learning. Case studies and Practical implementation.

TEXT BOOKS/ REFERENCES:

1. Deep Learning, Ian Goodfellow, Yoshua Bengio and Aeron Courville, MIT Press, First Edition, 2016.
2. Deep Learning, A practitioner’s approach, Adam Gibson and Josh Patterson, O’Reilly, First Edition, 2017.
3. Hands-On Learning with Scikit-Learn and Tensorflow, Aurelien Geron, O’Reilly, First Edition, 2017.
4. Deep Learning with Python, Francois Chollet, Manning Publications Co, First Edition, 2018.
5. Python Machine Learning by Example, Yuxi (Hayden) Liu, First Edition, 2017.
6. A Practical Guide to Training Restricted Boltzmann Machines, Geoffrey Hinton, 2010,

7. https://www.cs.toronto.edu/~hinton/absps/guideTR.pdf

CO – PO Affinity Map															
PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PSO2**	**PSO3**
CO1	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-
CO3	2	2	3	2	2	-	-	-	-	-	-	-	-	-	-
CO4	2	1	3	3	3	-	-	-	-	-	-	-	-	-	-

Course Code CS830	Course name Fundamentals of Network Biology :Theory And Applications	L-T-P-Credits 3 0 1 4	Year of Introduction 2020

Course Objectives

The aim of this course is to introduce students to the areas of network biology and network medicine, and to familiarize students with the process of reading, analysing, and critically evaluating the primary scientific literature. This course explores some of the methodologies in network biology and their implications. Finally, this course discusses the strategies that can be used to construct and analyze biological networks.

Course Outcome

CO1	Knowledge of the fundamental tools for studying real world networks, mathematical models of network structure, computational methods for analyzing network data & theories of structures and processes taking place on networks.
CO2	Ability to compare and analyze different solutions for large network problems with respect to network performance measures, structure of various kinds of networks etc.
CO3	Understanding of techniques applicable in complex network data sets for solving network problems, and to familiarize with modern network tools to analyze data.
CO4	Interpretation and use of network based cutting edge techniques like machine learning and deep learning.
CO5	Acquire knowledge about designing of various algorithms to solve large real-world network problems, devise models of network structure to predict the behavior of networked systems.

Course Content

UNIT-I

Graphs and Networks: Review of basic Graph Theory including algorithms- Dijkstra, Prims, Kruskal and Maximal flow and min cut algorithm, Matching and Assignments; Topological measures: diameter, geodesic path and girth; Clustering ;Motifs; Social networks: web graph, internet graph, citation graphs; Spectral graph partitioning ; Hierarchical clustering-Girvan and Newman algorithm

UNIT-II

Network models: Random graphs- Small world, Clustering coefficient - Power Laws and Scale-Free Networks – Hubs; Models of network formation - Watts-Strogatz model, Erdos-Renyi model Barabasi-Albert model (growth and preferential attachment, Degree dynamics, non-linear preferential attachment); The Internet and the World Wide Web: Structure of the World Wide Web; Variants of biological network-protein, genetic, signal transduction and metabolic networks.

UNIT-III

Probabilistic Graphical Models: Probabilistic reasoning-Random variables and joint distributions; Bayesian Network (BN) representation; D-separation- Algorithm for D-separation; Undirected Graphical Models-Gibbs distribution and Markov networks – Markov network independencies – Factor graphs – Learning parameters; Gaussian Network Models- Gaussian Bayesian networks –Multivariate Gaussians , Gaussian Markov Random Fields ;The Junction tree algorithm.

UNIT-IV

Machine learning techniques for network biology: Graph Convolutional Neural Network (GCNN)-prediction of genes and protein interface; Representation learning on graphs; SVM classifier and network-based feature extraction methods to predict human essential genes.

Unit V

Deep Learning for Network Biology: Network propagation and node embeddings; Graph autoencoders and deep representation learning; Heterogeneous networks; Tensor flow examples for biomedical networks implementation, Human diseases

References:

1. Dougles West, "Introduction to Graph Theory", Second Edition, PHI Learning Private Limited, 2011.
2. Network Medicine: Complex Systems in Human Disease and Therapeutics 1st Edition- By Joseph Loscalzo, Albert-Laszlo Barabasi, And Edwin K. Silverman.
3. Relevant research papers
    a. Ramirez, Ricardo, et al. "Classification of Cancer Types Using Graph Convolutional Neural Networks." Frontiers in Physics 8 (2020): 203.
    b. Fout, Alex, et al. "Protein interface prediction using graph convolutional networks." Advances in neural information processing systems. 2017.
    c. Hamilton, William L., Rex Ying, and Jure Leskovec. "Representation learning on graphs: Methods and applications." arXiv preprint arXiv:1709.05584 (2017).
    d. Dai, Wei, et al. "Network Embedding the Protein–Protein Interaction Network for Human Essential Genes Identification." Genes 11.2 (2020): 153.
    e. Azhagesan, Karthik, Balaraman Ravindran, and Karthik Raman. "Network-based features enable prediction of essential genes across diverse organisms." PloS one 13.12 (2018): e0208722.
4. ISMB 2018 Tutorial- Deep Learning for Network Biology available at: http://snap.stanford.edu/deepnetbio-ismb/index.html#outline
5. Daphne Koller, Nir Friedman, Probabilistic Graphical Models- Principles and Techniques, 1e, MIT Press, 2009.
6. WenJun Zhang, Foundations of Network Biology, 2018.

CO – PO Affinity Map

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO1	3	1	2	1	-	-	-	-	-	-	-	-	-	-	-
CO2	2	3	2	2	2	-	-	-	-	-	-	-	-	-	-
CO3	2	1	3	3	3	-	-	-	-	-	-	-	-	-	-
CO4	2	1	3	3	-	-	-	-	-	-	-	-	-	-	-
CO5	1	2	3	1	2	-	-	-	-	-	-	-	-	-	-