M.TECH DATA SCIENCE

CURRICULUM 2021

GENERAL INFORMATION

Course Outcomes (CO) – Statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.

Program Outcomes (POs) – Program Outcomes are statements that describe what students are expected to know and be able to do upon graduating from the Program. These relate to the skills, knowledge, attitude and behaviour that students acquire through the program. Program outcomes should be consistent with graduate attributes prescribed by NBA.

Graduate Attributes prescribed by NBA for M-Tech Program

GA1: Scholarship of knowledge

GA2: Critical thinking

GA3: Problem solving

GA4: Research skill

GA5: Usage of modern tools

GA6: Collaborative and multidisciplinary work

GA7: Project management and finance

GA8: Communication

GA9: Lifelong learning

GA10: Ethical practices and social responsibility

GA11: Independent and reflective learning.

Scope

This course aims at preparing students in the area of data science especially in data driven modeling and scientific computation. Recent advances in computing-hardware platforms (Nvidia CPU-GPUs, and Intel-Altera CPU-FPGA) , Artificial Intelligence software platforms (like Torch, Theano and Tensor-flow) and sensor technology (camera, lidar, ultrasonic sensors) has resulted rapid progress in machine -cognition tasks and is expected that machines will soon surpass the humans in visual and audio perception capabilities. This MTech course is tuned to cater to the demands in terms of skills required of the new scenario.

Program Outcomes

Graduates of this program will be able to

PO1: Develop an in depth understanding about the principles, tools and techniques pertinent to data science (GA1)

PO2: Apply the principles of data science to solve real life problems in various fields of Engineering, Physical and Natural Sciences. (GA2 & GA3)

PO3: Implement state of the art data analysis techniques in different computing platforms (GA5)

PO4: Arrive at innovative solutions for problems pertinent to data analysis in multiple domains (GA4 & GA6)

PO5: Able to identify and execute projects relevant to data analysis that will benefit the society (GA7, GA9, GA10 & GA11)

PO6: Able to communicate the findings of their analysis to scientific community through quality publications (GA4, GA9 & GA11)

Program Educational Objectives (PEOs)

Graduates of the program will be able to

PSO1- Understand the mathematical concepts behind the algorithms employed in data science and analyse the existing algorithms from a mathematical perspective.

PSO2 – Understand and implement the state-of-the-art bigdata platforms and high-performance computing platforms for solving problems related to data science.

PSO3 – Conduct research in the area of data science and pursue a career in research and development pertinent to data science.

PSO4 – Apply the tools and techniques of data science in the areas of NLP, Healthcare, Cyber Security, Smart Grids and Game Physics.

SEMESTER I

Category	Course Code	Title	L-T-P	Credit
FC	21MA602	Computational Linear Algebra	2 1 0	3
FC	21DS601	Optimization Techniques for Data Science	2 1 0	3
FC	21DS602	Machine Learning	3 0 3	4
FC	21DS603	Data Structures and Algorithms for Data Science	2 1 0	3
SC		SC-1	2 1 0	3
SC	21RM607	Research Methodology	2 0 0	2
HU	21HU601	Amrita Values Program		P/F
HU	21HU602	Career Competency - I		P/F
		Total	20	18

SEMESTER II

Category	Course Code	Title	L-T-P	Credit
FC	21DS611	Deep Learning	3 0 3	4
SC		SC-2	2 1 0	3
SC		SC-3	2 1 0	3
SC		SC-4	2 1 0	3
E		Elective 1	2 1 0	3
E		Elective 2	2 1 0	3
HU	21HU603	Career Competency - II	0 0 2	1
		Total	22	20

SEMESTER III

Category	Course Code	Title	L-T-P	Credit
E		Elective 3	2 1 0	3
E		Elective 4	2 1 0	3
P	21DS798	Dissertation I	0 0 10	10
		Total	16	16

SEMESTER IV

Category	Course Code	Title	L-T-P	Credit
P	21DS799	Dissertation II	0 0 16	16
		Total	16	16

LIST OF COURSES

FOUNDATION CORE

Course Code	Title	L-T-P	Credit
21MA602	Computational Linear Algebra	2 1 0	3
21DS601	Optimization Techniques for Data Science	2 1 0	3
21DS603	Data Structures and Algorithms for Data Science	2 1 0	3
21DS602	Machine Learning	3 0 3	4
21DS611	Deep Learning	3 0 3	4

SUBJECT CORE

Course Code	**Title**	**L-T-P**	**Credit**
21DS631	Embedded Computing & Realtime OS for Data Science	2 0 1	3
21RM607	Research Methodology	2 0 0	2
21DS632	Introduction to Probabilistic Graphical Models	2 0 1	3
21DS633	Scientific Computing	2 0 1	3
21DS634	Text Mining and Analytics	2 0 1	3
21DS635	Big Data Framework for Data Science	2 1 0	3
21DS636	Statistical Modelling	2 1 0	3
21DS637	Advanced Data Visualization and Analytics	3 0 0	3

PROFESSIONAL ELECTIVES

Course Code	Title	L-T-P	Credit
21DS701	AI Applications for Power Systems	2 0 1	3
21DS702	Deep Learning in Genomics and Biomedicine	2 1 0	3
21DS703	Deep Learning for Biomedical Data Analysis	2 1 0	3
21DS704	Deep Learning for Speech Signal Processing	2 0 1	3
21DS705	Social Media Analytics	2 0 1	3
21DS706	Deep Learning for Visual Recognition	2 1 0	3
21DS707	Deep Learning for Cyber Security	2 1 0	3
21DS708	Complex Systems in Engineering, Finance & Biology: Modelling & Analysis	2 1 0	3
21DS709	High Performance Computing	2 0 1	3
21DS710	Multiscale Fluid Modelling	2 0 1	3
21DS711	Computer Vision	2 1 0	3
21DS712	Reinforcement Learning	2 1 0	3
21DS713	Blockchain Technology	2 1 0	3
21DS714	Predictive Analytics for Internet of Things	2 1 0	3
21DS715	Cloud Computing and Security in the Cloud	2 1 0	3

SEMESTER I

21MA602	Computational Linear Algebra	L-T-P-C: 2-1-0-3

Course Objectives

- The course will lay down the basic concepts and techniques of linear algebra and calculus needed for subsequent study.
- The course will explore the concepts initially through computational experiments and then try to understand the concepts and theory behind it.
- The course will provide an appreciation of the wide application of these disciplines within the scientific world.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Use computational techniques and algebraic skills essential for the study of systems of linear equations, matrix algebra, vector spaces, eigenvalues and eigenvectors, orthogonality and diagonalization. (Computational and algebraic skills).
- **CO2:** Use visualization, spatial reasoning, as well as geometric properties and strategies to model, solve problems, and view solutions, especially in R2 and R3.
- **CO3:** Conceptually extend these results to higher dimensions (Geometric Skills) and critically analyze and construct mathematical arguments that relate to the study of introductory linear algebra. (Proof and Reasoning).

CO-PO Mapping

PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO										
CO1	2	3	2	3	3	3	3	-	3	3
CO2	3	3	2	3	3	3	2	-	3	2
CO3	1	3	3	3	3	3	2	-	3	-

Syllabus

Matrices and Gaussian Elimination – introduction, geometry of linear equations, Gaussian elimination, matrix multiplication, inverses and transposes. Vector spaces and Linear equations– vector spaces and subspaces, linear independence, basis and dimension, four fundamental subspaces. Orthogonality - perpendicular vectors and orthogonal subspaces, inner products and projections onto lines, projections and least square applications, orthogonal basis, orthogonal spaces, orthogonal matrices, Gram Schmidt orthogonalization, FFT. Eigenvalues and Eigenvectors – introduction, diagonal form of a matrix, difference equations and the powers of A^k, Positive Definite Matrices - minima, maxima and saddle points, tests for positive definiteness, semi-definite and indefinite matrices, Singular Value Decomposition, Iterative methods for Ax = b, Introduction to special matrices - Fourier transforms : discrete and continuous, shift matrices and circulant matrices, Kronecker product, sine and cosine transforms from Kronecker sums, Toeplitz matrices and shift invariant filters, graphs and Laplacians and Kirchhoff's laws, clustering by spectral methods and k-means, completing rank one matrices, orthogonal Procrustes problem, distance matrices

Textbook / References

Gilbert Strang, Linear Algebra and its Applications, Fourth Edition, Cambridge University Press. 2009.

Gene H. Golub and V. Van Loan, Matrix Computations, Third Edition, John Hopkins University Press, Baltimore, 1996.

David C. Lay, Linear Algebra and Its Applications, Pearson Addison Wesley, 2002.

Strang, Gilbert. Linear algebra and learning from data. Cambridge: Wellesley-Cambridge Press, 2019.

Evaluation Pattern

Assessment component	**Type of Assessment**	**Minimum Number of Assessments**	**Weightage (%)**
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS601	**Optimization Techniques for Data Science**	**L-T-P-C: 2-1-0-3**

Course Objectives

- The course will lay down the basic concepts and techniques of optimization theory needed for subsequent study.
- The course provides a thorough understanding of how optimization problems are solved, and some experience in solving them.
- The course will provide the background required to use the methods in research work and/or applications.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand the importance of optimization for data science and apply basic concepts of mathematics to formulate and understand optimization problem.
- **CO2:** Understand the analytical methods for solving constrained optimization problems and unconstrained optimization problems.
- **CO3:** Understand various applications arising in different scientific domains such as control, signal processing, machine learning and communications.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	1	2	3	3	3	3	3	-	-	-
CO2	3	3	3	3	3	3	2	-	2	-
CO3	2	3	3	3	3	3	-	-	3	3

Syllabus

Introduction - mathematical optimization, least-squares and linear programming, convex and nonlinear optimization. convex sets, Convex optimization problems - optimization problem in standard form, convex optimization problems, quasi-convex optimization, linear optimization, quadratic optimization, generalized inequality constraints, semi definite programming, vector optimization. Duality, approximation and fitting, statistical estimation, geometric problems, Unconstrained minimization- gradient descent method, steepest descent method, Newton's method. Equality constrained minimization - equality constrained minimization, eliminating equality constraints, Newton's method with equality constraints, infeasible start Newton method, and implementation. Interior-point methods -inequality constrained minimization, logarithmic barrier function and central path, barrier method, L1 Norm optimization methods. Introduction to Neural Networks - Alternating direction method of multipliers (ADMM) and applications (16 applications mentioned by Prof. Stephen Boyd)

Textbook / References

Kalyanmoy, Deb. Optimization for engineering design: Algorithms and examples. Prentice-Hall of India Pvt. Limited, 2012.

Chong, Edwin KP, and Stanislaw H. Zak. An introduction to optimization. John Wiley & Sons, 2004.

Bhatti, M. Asghar. Practical Optimization Methods: With Mathematica® Applications. Springer Science & Business Media, 2012.

Stephen P. Boyd, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.

Lecture notes on optimization

Evaluation Pattern

Assessment component	**Type of Assessment**	**Minimum Number of Assessments**	**Weightage (%)**
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS602	Machine Learning	L-T-P-C: 3-0-3-4

Course Objectives

- This course provides the basic concepts of machine learning.
- This course provides the implementation of machine learning algorithms in Matlab/Python.
- This course serves as the prerequisite for data analysis using machine learning algorithms.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** To understand the concepts behind machine learning algorithms.
- **CO2:** To implement machine learning algorithms in Matlab/Python.
- **CO3:** To evaluate machine learning models.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	3	3	3	-	2	-
CO2	3	3	3	2	3	3	-	3	3	2
CO3	3	2	2	2	2	3	3	-	3	2

Syllabus

Regression - Linear, Logistic - Supervised Learning – Unsupervised Learning – K-Means Clustering – K-Nearest Neighbour -Naive Bayes - Decision Tree – Kernel Method: Support Vector Machine – Dimensionality Reduction Methods: PCA, SVD – Feature Selection -Ensemble Methods: Bagging and Boosting – Evaluation of Classification Methods: k-fold cross validation, leave-one-out cross validation - standard metrics -ROC-curve – Data and Feature Visualization – Machine learning algorithms applied for signal and image analysis.

Textbook / References

Soman, K. P., Loganathan, R., & Ajay, V, "Machine learning with SVM and other kernel methods", PHI Learning Pvt. Ltd., 1st Edition, 2009.

Soman, K. P., Shyam Diwakar, and V. Ajay. Data mining: theory and practice [with CD]. PHI Learning Pvt. Ltd., 1st Edition 2006.

Bishop, Christopher M. "Pattern recognition and Machine Learning", Springer, 1st Edition 2006.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS603	Data Structures and Algorithms for Data Science	L-T-P-C: 2-1-0-3

Course Objectives

- This course aims at introducing the concept of data structure hierarchy.
- It will also expose the students to the basic and higher order data structures.
- Further the students will be motivated to apply the concept of data structures to various engineering problems.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Choose an appropriate data structure as applied to a specified problem.
- **CO2:** Use various techniques for the representation of the data in the real world
- **CO3:** Develop application using data structures.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	3	2	2	-	3	2	2
CO2	3	3	2	3	2	3	1	1	2	2
CO3	3	2	3	2	2	2	-	3	2	3

Syllabus

Data Structures – Arrays – List - Linked list - Stack - Queues, Recursion – Dictionaries - Hashing – Graphs – Directed and Undirected graphs - Graph Traversals and Searching – Shortest paths - Trees – Binary Trees, AVL Trees, Tries and pattern matching - Probabilistic Data Structures – Functional Data Structures

Algorithms – Big O notations, Asymptotic analysis, Sorting Algorithms, and analysis – Greedy approach – Divide-and-conquer- Dynamic Programming – NP-Completeness

Textbook / References

Jeff Erickson, "Algorithms", First edition, 2019 [Available on: https://jeffe.cs.illinois.edu/teaching/algorithms/book/Algorithms-JeffE.pdf]

Morin, Pat. Open Data Structures: An Introduction. Vol. 2. Athabasca University Press, 2013.

Michael T. Goodrich and Roberto Tamassia, "Algorithm Design Foundations, Analysis and Internet Examples," John Wiley and Sons, 2003.

Michael T. Goodrich and Roberto Tamassia, "Data Structures and Algorithms in Java," Fourth Edition, John Wiley, and Sons, 2004.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS631 Embedded Computing & RTOS for Data Science Applications L-T-P-C: 2-0-1-3

Course Objectives

- The course will provide the importance and applications of embedded systems in modern applications
- The course will pave the way for understanding the various sources of data stream from an embedded system point of view and recording this data streams for processing
- This will enable the students to develop various system and analyze the data from the developed system for decision making.
- The course will enable the student with basic real-time operating system concepts for application development.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Enabling the student with fundamentals of micro-controller architecture, building components and embedded data streaming devices.
- **CO2:** To program various micro-controllers, application development and data streaming using various sensors.
- **CO3:** Working with Free RTOS for developing real-time data streaming and intelligent applications.
- **CO4:** To develop real-time embedded system application in healthcare, agriculture, autonomous car and other data streaming systems.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	1	2	2	2	1	-	-	1	-
CO2	3	3	1	2	1	2	-	2	2	2
CO3	3	3	3	3	3	3	-	3	2	3
CO4	-	1	2	2	2	-	-	2	2	3

Syllabus

Introduction to Embedded systems, AI enabled embedded system applications, Embedded nodes as data source in various applications, Micro-controllers and its basic, Micro-controller Instruction Set Architecture – RISC and CISC, Basic Embedded Processor/Microcontroller Architecture, Memory System Architecture-Caches-Virtual Memory, Memory Devices and their Characteristics-RAM, ROM, UVROM, EEPROM, Flash Memory, DRAM , I/O Devices - Timers and Counters - Watchdog Timers - - Interrupt Controllers - DMA Controllers - A/D and D/A Converters -Displays , GPIO, Analog Sensors interfacing and data recording , Networked Embedded systems and protocols, Real-time concepts, real-time operating systems, Required RTOS services/capabilities (in contrast with traditional OS). Software development for data acquisition, fundamentals of wireless networks for embedded system, Interfacing and Integration of microcontroller-based systems. Examples of Industrial process automation, software development using python and microcontrollers, Introduction to data streams and analytics. Data visualization using python tools, Machine learning techniques on sensor data streams, Introduction to hardware accelerated embedded systems like Jetson Tx1, Raspberry PI, Jetson-NANO for Data science embedded application deployment.

Textbook / References

Russell, David J. "Introduction to embedded systems: using ANSI C and the arduino development environment." Synthesis Lectures on Digital Circuits and Systems 5.1 (2010): 1-275.

Wang, K. C. "Embedded real-time operating systems." Embedded and Real-Time Operating Systems. Springer, Cham, 2017. 401-475.

Brian Amos,"Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools", PACKT publishing, 15 May, 2020

Bhateja, Vikrant, Suresh Chandra Satapathy, and Hassan Satori, eds. Embedded Systems and Artificial Intelligence: Proceedings of ESAI 2019, Fez, Morocco. Vol. 1076. Springer Nature, 2020.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

SEMESTER II

21DS611	**Deep Learning**	**L-T-P-C: 3-0-3-4**

Course Objectives

- This course provides the basic concepts of deep learning and implementation using Matlab/Python.
- This course provides the application of deep learning algorithms in signal and image data analysis.
- This course covers the concept of deep learning algorithms such as transfer learning and attention models for signal and image analysis.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** To understand the fundamentals of deep learning.
- **CO2:** To implement deep learning algorithms using Matlab/Python.
- **CO3:** To implement deep learning models for signal and image analysis.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	3	3	2	-	2	-
CO2	3	3	3	2	3	3	-	3	2	2
CO3	3	3	3	2	3	3	1	2	2	3

Syllabus

Deep Neural Networks (DNN) –Convolutional Neural Network (CNN) – Recurrent Neural Network (RNN) : Long-Short- Term-Memory (LSTM) - Graph based Neural Network (GNN) - Preprocessing: Noise Removal using deep learning algorithms - Feature Extraction - Signal Analysis: Time Series Analysis, CNNs, Autoencoders. Image Analysis: Transfer Learning, Attention models- Ensemble Methods for Signal and Image Analysis.

Textbook / References

Bishop C.M, "Pattern Recognition and Machine Learning", Springer, 1st Edition, 2006.

Goodfellow I, Bengio Y, Courville A, & Bengio Y, "Deep learning", Cambridge: MIT Press, 1st Edition, 2016.

Soman K.P., Ramachandran K. I, Resmi.N.G, "Insight into Wavelets: From Theory into Practice", PHI Pvt.Ltd., 3rd Edition, 2010.

Soman K.P, Ramanathan. R, "Digital Signala nd Image Processing – The Sparse Way", Elsevier, 1st Edition, 2012.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS632 INTRODUCTION TO PROBABILISTIC GRAPHICAL MODELS L-T-P-C: 2-0-1- 3

Course Objectives

- The main objective of the course is to introduce the fundamental concepts of probabilistic graphical models.
- To explore the applications of probability theory and graphical models in data analysis.
- To provide connection between the concepts of mathematics and computational thinking with probabilistic graphical models.

Course Outcomes

After completing this course, the students will be able to

CO1: Model engineering problems using the fundamental concepts of probability

CO2: Apply the concept of probabilistic graphical models to solve problems pertinent to data science.

CO3: Analyse different probabilistic models developed for describing a given system.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	1	-	-	3	-	2	-
CO2	1	3	1	1	-	-	-	1	2	3
CO3	1	2	2	1	-	-	-	2	2	2

Syllabus

Samples, Events, Event space, Probability Space, Random Variables, Independence and Conditional Independence, Conditional Probability, Joint Probability, Bayes' theorem Joint and Marginal Probability, Estimation Theory - Maximum Likelihood Estimators. Probabilistic Graphical Models: Direct and undirected model, Inference from Direct and undirected graphical model, Structured and Unstructured graphical models, Partition Function, D-Separation, Decision Analysis, Decision Trees, Influence Diagrams, Factor Graphs, Sampling from Graphical Models. Markov Process and Markov Chain.

Textbooks / References

Koller, Daphne, and Nir Friedman. Probabilistic graphical models: principles and techniques. MIT press, 2009.

Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT press 2016

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS634	Text Mining and Analytics	L-T-P-C: 2-0-1-3

Course Objectives

- This course aims to provide an insight into the concepts of Natural Language Processing and its applications.
- This course helps the students to implement NLP applications using deep learning algorithms.
- This course helps to understand various word/text representation algorithms.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Use different word/text representation methods to see how words are related to each other.
- **CO2:** Model different NLP applications using Machine Learning/Deep learning algorithms
- **CO3:** Implement different deep learning models to solve real-time NLP problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	2	3	-	-	2	1
CO2	3	3	2	2	3	3	-	2	2	2
CO3	3	3	2	2	3	3	-	3	2	3

Syllabus

Introduction to Natural Language Processing -Words -Regular Expressions -N-grams -Language modelling - Part-of-Speech Tagging - Named Entity Recognition – Syntactic and Semantic Parsing – Morphological Analysis

Text Representation and Transformation - Vector space models -Bag-of-Words -Term Frequency - Inverse Document Frequency - Word Vector representations: Word2vec, GloVe, FastText, BERT – Topic Modelling

Neural language models - Recurrent Neural Network - Long Short-Term Memory Networks - Encoder-decoder architecture - Attention mechanism - Transformer networks

Text classification – Sentiment Analysis – Neural Machine Translation - Question answering - Text summarization.

Textbook / References

Daniel Jurafsky and James H. Martin, "Speech and Language Processing," 3rd edition, 2020. [Available on: https://web.stanford.edu/~jurafsky/slp3/ed3book_dec302020.pdf]

Christopher Manning and Hinrich Schutze, "Foundations of statistical natural language processing," MIT press, 1999.

Jacob Eisenstein, "Introduction to natural language processing," Illustrated edition, The MIT press, 2019.

Bengfort, Benjamin, Rebecca Bilbro, and Tony Ojeda. Applied text analysis with python: Enabling language-aware data products with machine learning. " O'Reilly Media, Inc.", 2018.

Ronan Collobert, Jason Weston, Léon Bottou, Michael Karlen, Koray Kavukcuoglu, and Pavel Kuksa, "Natural language processing (almost) from scratch," Journal of machine learning research 12, no. ARTICLE (2011): 2493-2537.

Yoav Goldberg, "Neural network methods for natural language processing," Synthesis lectures on human language technologies 10, no. 1 (2017): 1-309.

Yoav Goldberg, "A primer on neural network models for natural language processing," Journal of Artificial Intelligence Research 57 (2016): 345-420.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80

External	Term Project	1	20

21DS633	**Scientific Computing**	**L-T-P-C: 2-0-1-3**

Course Objectives

- This course helps students to understand the established conventional computational techniques.
- This course helps students to understand the concepts related to probability, statistics, linear algebra and partial differential equations and the ways to solve those equations.
- This course aims to help students in implementing the computational methods using MATLAB and Python.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Develop an understanding of theoretical and computational fundamentals of scientific computing.
- **CO2:** Analyse and solve problems pertinent to data science with the application of relevant computational techniques using MATLAB and Python.
- **CO3:** Model different engineering/physical/natural systems.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	1	1	1	3	-	2	-
CO2	2	2	3	2	2	2	1	3	2	2
CO3	3	3	3	3	3	3	2	-	2	3

Syllabus

Linear system of equations, Eigenvalues and Eigenvectors, Taylor series, Numerical differentiation, Numerical integration, Higher order accuracy schemes for integration and differentiation, Ordinary differential equations, Partial Differential Equations, Iterative methods, Numerical methods: error analysis, stability and convergence, Runge-Kutta methods, Fourier Transforms, Discrete and Fast Fourier Transforms, Least-square and polynomial fitting methods, Dynamic mode decomposition, Koopman Theory.

Textbook / References

Gilbert Strang, Differential Equations and Linear Algebra, Wellesley-Cambridge Press, 2015.

Kutz, J. Nathan, Data-Driven Modeling & Scientific Computation: Methods for Complex Systems & Big Data, Oxford University press, 2013.

Arfken, George. B., and Weber, Hans. J., Mathematical Methods for Physicists, Sixth Edition, Elsevier Academic Press, 2005.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS636	Statistical Modeling	L-T-P-C: 2-1-0-3

Course Objectives

- The course will lay down the basic concepts and techniques of statistical modeling, to develop the students' ability to deal with numerical and quantitative issues in business.
- The course provides a thorough understanding of how regression problems are solved, while working with real time examples.
- Enable the use of statistical, graphical and algebraic techniques wherever relevant
- To have a proper understanding of Statistical applications in Engineering, Economics and Management
- The course will also provide the foundation for research and development work and applications.

Course Outcomes

After completing this course, the students will be able to

- **CO1**: Understand the mathematical basis of the general linear model and its extensions to multilevel models and logistic regression.
- **CO2**: Use the open-source programming language Python for the analysis of data arising from both observational studies and designed experiments.
- **CO3**: Understand the role of statistical modelling in discovering information, making predictions and decision making in a range of applications including medicine, engineering, science and social science.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	1	2	3	3	3	3	3	-	2	-
CO2	3	3	3	3	3	3	-	3	2	2
CO3	2	3	3	3	3	3	1	-	2	3

Course Pre-requisites

Calculus, algebra, matrix algebra, and programming statistical package Python3 and the math-friendly documentation language Latex.

Syllabus

Probability, Random Variables & Probability Distributions. Sampling, analysis of sample data-Empirical Distributions, Sampling from a Population Estimation, confidence intervals, point estimation--Maximum Likelihood, Probability mass functions, Modeling distributions, Relationships between variables and Estimation, Hypothesis testing- Z, t, Chi-Square & F-test. ANOVA & Designs of Experiments - Single, Two factor ANOVA, Factorials ANOVA models. Linear least squares, Correlation & Regression Models-linear regression methods, Ridge regression, LASSO, univariate and Multivariate Linear Regression, probabilistic interpretation, Regularization, Logistic regression, locally weighted regression.

Exploratory data analysis, Time series analysis, Analytical methods – ARIMA and SARIMA.

Textbooks/References

Think Stats 2e, Exploratory Data Analysis in Python, Allen B. Downey, O'REILLY', Green Tea Press.

Python Crash Course, 2nd Edition: A Hands-On, Project-Based Introduction to Programming by Eric Matthes.

Practical Statistics for Data Scientists, by Peter Bruce and Andrew Bruce, O'REILLY'

Julian J. Faraway. Extending the Linear Model with R – Generalized Linear, Mixed Effects and Nonparametric Regression Models, Second Edition, CRC Press 2016.

Michael Friendly and David Meyer. Discrete Data Analysis with R – Visualization and Modeling Techniques for Categorical and Count Data, CRC Press Dec 2015.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS637	Advanced Data Visualization and Analytics	L-T-P-C: 3-0-0-3

Course Objectives

- This course will provide knowledge on visualization design principles and deciding the type of visualization chart to choose for the given sets
- This course will teach on creating simple to advanced chart types using python modules and libraries
- This course will explore, visualize and analyze various types of data sets such as time series, geospatial and multimodal data
- This course helps the students to work on visualization tools and enable the students to understand the visual analytics such as dashboards and storytelling with a hands-on tutorial on tableau and PowerBI.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand the importance of Data Visualization and learn to create basic charts by applying visualization design principles
- **CO2:** Learn to create advanced visualization charts and analysis
- **CO3:** Explore and Analyse Time series, Geospatial and multimodal data
- **CO4**: Learn to build interactive/animated dashboards and construct data stories and communicate important trends/patterns in the datasets

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	2		1			-	1	2	-
CO2	2	3		2			-	2	2	2
CO3	2	2		3	1	1	2	2	2	2
CO4	3	2		2	3	1	-	3	2	3

Syllabus

Overview of Data Visualization – Importance and benefits of good data visualization– Design principles - Introduction to python libraries for visualization: seaborn, plotly express, pygal- Exploring Data – Reduce Items and Attributes: Filter and Aggregate - Creation of basic visualization: Histogram, Bar (Vertical and Horizontal) and Line Chart, Box plot, Scatter plot (Examples and Exercises to be given for practice). Color palettes – Creation of 3D Charts. Creation of Advanced Visualization: Heat Map– Facet Grid - Interaction Techniques: Manipulate View – Creation of interactive Network topologies and Trees

Visualization of Time series data: summary statistics and plotting aggregated views - Visualization of seasonality, trends and noise– working with multiple time series data – case study - Visualization of Geospatial data: spatial join - overlaying geospatial data to maps and adding special cues - Case Study-

Visualization of multimodal data and analysis-case study sensor data and health care, genome and biomedical data

Business Analytics and Visualization Tools: Tableau, PowerBI, Creating Interactive Dashboards and charts to organize data using visualization principles- Data Storytelling – reading data in-depth, identifying critical messages and communicating these messages in most effective way

Textbooks/References:

Tamara Munzner, Visualization Analysis and Design, A K Peters Visualization Series, CRC Press, 2014.

Scott Murray, Interactive Data Visualization for the Web, O'Reilly, 2013.

VanderPlas J. Python data science handbook: essential tools for working with data O'Reilly Media. Inc", 2016

Alberto Cairo, The Functional Art: An Introduction to Information Graphics and Visualization, New Riders, 2012

Nathan Yau, Visualize This: The Flowing Data Guide to Design, Visualization and Statistics, John Wiley & Sons, 2011.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS635	BIGDATA FRAMEWORK FOR DATASCIENCE	L-T-P-C: 2-0-1-3

Course Objectives

- To provide the importance of functional programming.
- To implement various big data concepts using Scala programming language, which is a functional programming language.
- Ability to solve various real time problems using big data concepts.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand Functional representations.
- **CO2:** Model Computations as a Map-Reduce problem.
- **CO3:** Imbibe the programming skill to use Spark for Big data manipulation

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	1	1	1	2	2	2	-
CO2	3	3	3	2	2	2	-	2	2	-
CO3	2	3	3	3	3	3	-	3	2	3

Syllabus

New generation Big data using Functional Programming in Scala: Basic Syntax-type inference and static types-function types and value types, closures. Immutability and immutable types-generic type Parameters-Recursive arbitrary collections-cons list-Iterative arbitrary collections-Arrays-Tail recursion-factorial example-functional abstractions with examples-square root, fixed point, sequence summations. Higher order functions-MapReduce Template-Pattern Matching syntax. Basic entity classes and object in Scala. Apache Spark: -Resilient Distributed Data Sets-Creating RDDs, Lineage and Fault tolerance, DAGs, Immutability, task division and partitions, transformations and actions, lazy evolutions and optimization -Formatting and housing data from spark RDDs-Distributed File systems HDFS and Tachyon-Persistence. Setting up a standalone Spark cluster-: spark-shell, basic API, Modules Core-Key/Value pairs and other RDD features, MLlib-examples for bi-class SVM and logistic regression, Data Frames and Datasets. Creating data frames from RDDs. Using Spark SQL to query data frames. NoSQL aggregate data bases. Some analytics case studies

Textbooks / References

Learning Spark: Lightning-Fast Big Data Analysis 1st Edition by Holden Karau , Andy Konwinski, Patrick Wendell, MateiZahariaProgramming in Scala: A Comprehensive Step-by-Step Guide Third Edition by Martin Odersky, Lex Spoon, Bill Venners. High Performance Spark: Best Practices for Scaling and Optimizing Apache Spark 1st Edition, by Holden Karau, Rachel WarrenScala for the Impatient 2nd Edition, by Cay S. HorstmannSpark: The Definitive Guide: Big Data Processing Made Simple 1st Edition, Kindle Edition by Bill Chambers, MateiZaharia.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21RM607	Research Methodology	L-T-P-C: 2-0-0-2

Course Objectives

This course will

- Introduce the concepts involved in scientific research
- Detail the process of conducting a literature review for a given scientific problem
- Impart the basics of scientific/technical writing

Course Outcomes

After completing this course, the students will be able to

- **CO1**: Understand the concepts related to scientific research
- **CO2**: Perform a literature survey and identify open problems in the chosen area of research
- **CO3**: Prepare a research paper/dissertation to communicate their contributions to scientific community

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	1	-	-	3	1	1	-	-	3	-
CO2	-	-	-	1	2	3	-	-	3	2
CO3	-	-	-	-	2	3	-	-	3	2

Syllabus

Unit I:

Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in research.

Unit II:

Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science.

Textbooks / References

Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8th Edition, McGraw-Hill, 2011

C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers

Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc. Michael P. Marder," Research Methods for Science", Cambridge University Press, 2011

T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6 edition July 2012.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

PROFESSIONAL ELECTIVES

21DS701	**AI Applications for Power Systems**	**L-T-P-C: 2-0-1-3**

Course Objectives

- The course provides fundamental understanding of the electric power system and underlying dynamics of their operation.

- The course will impart the basic concepts and principles of power system analysis.
- The course will provide knowledge of appropriate AI framework for solving power system problems.
- The course will empower the students to integrate the concepts of power systems into AI research.

Course Outcomes

After completing this course, the students will be able to,

- **CO1:** Understand the fundamental concepts about conventional power system and Smartgrid.
- **CO2:** Understand the mathematics behind the operation of power grids and various optimization problems such as economic dispatch, optimal power flow etc.
- **CO3:** Develop the basic knowledge to apply appropriate AI framework for solving power system problems.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	--	1	--	2	2	3	-	-	2	1
CO2	1	2	1	2	3	3	3	-	2	2
CO3	2	3	3	3	3	2	-	2	2	3

Syllabus

Three-phase Systems-Overview of Power Grid-Complex power-Per Unit systems- Optimization Principles-Economic Dispatch-Power Flow Analysis and OPF-Fundamentals of Power System Stability-Distribution Systems-Microgrid and Storage-Electric Power Markets- Renewable Energy Optimization-Forecasting of Renewable Energy Sources-AI for Demand Side Management-Other AI Applications in Power Systems (Hydro-Thermal Scheduling, Transmission Planning, Maintenance Scheduling etc.)

Textbook / References

Arthur R. Bergen, and Vijay Vittal. Power systems analysis. Prentice Hall, 2000.

Stephen P. Boyd, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.

Allen J. Wood and Bruce Wollenberg. Power Generation Operation and Control. Wiley Press, 2006.

Kevin Warwick. Artificial Intelligence Techniques in Power Systems. IET Power and Energy Series, 2008.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS702	Deep Learning in Genomics and Biomedicine	L-T-P-C: 2-0-1-3

Course Objectives

- The course will lay down the basic concepts and techniques of Deep learning in Genomics and Biomedicine
- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- Goal of the course is to provide connection between the concepts of Deep learning in Genomics and Biomedicine.

Course Outcomes:

After completing this course, the students will be able to,

- **CO1:** To develop an understanding of the basic concepts in Genomics and Biomedicine.
- **CO2:** To implement the deep learning algorithms for Genomics data analysis.
- **CO3:** To apply the deep learning algorithms for Biomedicine data analysis.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	2	2	2	-	2	2
CO2	3	3	3	2	3	3	-	3	2	2
CO3	3	3	3	2	3	3	-	2	2	3

Syllabus

Introduction to Machine Learning - Genomics – DenseNets and Convolutional Nets for Genomics – Recurrent NN –Autoencoders and representation learning - Generative Models –Drug Discovery and protein structure: - imaging and electronic medical records - MoleculeNet – One shot Learning drug discovery - Case Studies.

Textbook / References

Goodfellow I, Bengio Y, Courville A, & Bengio Y, "Deep learning", Cambridge: MIT Press, 1st Edition, 2016.

Michael Nielsen, "Neural Networks and Deep Learning", Goodreads (eBook), 2013.

Bengio Y, "Learning Deep Architectures for AI, Foundations and Trends in Machine Learning", nowpublishers, 2009.

Weblink: https://genome.cshlp.org/content/26/7/990

Weblink: https://www.nature.com/articles/nmeth.3547

Weblink: https://academic.oup.com/nar/article/44/11/e107/2468300

Weblink: https://arxiv.org/abs/1512.00843

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	7 (each worth 10%)	70
External	Term Project	1	30

21DS709	High Performance Computing	L-T-P-C: 2-0-1-3

Course Objectives

- Provide understanding of high-performance computing (HPC) machines, their software and hardware architecture
- Enable design and development of high-performance programs and codes based on performance analysis
- Enable parallelization of computer codes and implement them in super-computing /HPC facilities

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand the operation and technicality of HPC machines and codes
- **CO2:** Develop algorithms and hardware setups for carrying out cluster computing
- **CO3:** Restructure conventional/serial codes into HPC compatible parallel codes

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	2	1	2	-	3	2	-
CO2	2	3	3	3	2	1	1	3	2	-
CO3	1	3	3	3	1	3	-	3	2	-

Syllabus

High Performance Computing (HPC) hardware architecture, Parallelization strategies, task parallelism, data parallelism, and work sharing techniques, Shared memory parallelism, Parallel programming with OpenMP and (POSIX) threads, Message passing with MPI, Execution profiling, timing techniques, and benchmarking for modern single-core and multi-core processors, High performance algorithms, Parallel scientific computing, Parallel data science algorithms, HPC libraries, Introduction to GPUs.

Textbook / References

K.R. Wadleigh, I.L. Crawford, Software Optimization for High Performance Computing: Creating Faster Applications, Hewlett-Packard professional books, Prentice Hall

B. Wilkinson, M. Allen, Parallel Programming: Techniques and Applications using Networked Workstations and Parallel Computers, Prentice Hall

G. Karniadakis, R. Kirby II, Parallel Scientific Computing in C++ and MPI, Cambridge University Press

J. Dongara, I. Foster, G. Fox, W. Gropp, K. Kennedy, L. Torczon, and A. White, Sourcebook of Parallel Programming, Morgan Kaufmann

Victor Eijkhout, Edmond Chow, Robert van de Geijn, Introduction to High Performance Scientific Computing, MIT Press, 2016

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	7 (each worth 10%)	70
External	Term Project	1	30

21DS708	COMPLEX SYSTEMS IN ENGINEERING, FINANCE & BIOLOGY: MODELLING & ANALYSIS	L-T-P-C: 2-0-1-3

Course Objectives

- The course will lay down the basic concepts of complex system theory required to model and analyse various physical systems

- It will explore the concepts initially through computational experiments and then try to understand the concepts/theory behind it.
- It will help the students to perceive the engineering problems using the fundamental concepts in engineering, finance and biology
- Another goal of the course is to provide connection between the concepts of complex system theory, mathematics and computational thinking

Course Outcomes

After completing this course, the students will be able to

- **CO1:** To enable the students to create mathematical models of physical and engineering systems
- **CO2:** To introduce state of the art techniques to analyze data obtained from nonlinear systems
- **CO3:** To apply the concepts of complex system theory to predict transitions that happen in physical and Engineering systems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	2	2	-	-	-	-	3	-	2	-
CO2	1	1	3	2	1	-	-	3	2	-
CO3	1	2	2	3	3	-	-	-	2	3

Syllabus

Definition of a complex system- Complex systems in engineering- Complex systems in nature & society- Modelling of complex systems-Introduction to dynamical system theory- standard models in dynamical systems-transitions in dynamical systems-bifurcations- Maps and flows- Chaos- Routes to chaos.

Analysis of chaotic data from experiments-basics of time series analysis-standard models in time series analysis-nonlinear time series analysis- phase space reconstruction- precursors to predict transitions in complex systems- critical slowing down- precursors based on recurrence-precursors based on multifractal formalism.

Emergence of order in complex systems-transitions as pattern formation-spatial early warning signals-complex networks-network properties as early warning measures-Networks in natural and engineering systems-Networks in biology-Networks in finance.

Applications in remote sensing- Applications in cyber security- Applications in physiology- Applications in finance-future of complex system theory.

Textbooks / References

N. Boccora, Modelling of Complex Systems, 2nd Edition, Springer 2010.

S. Strogatz, Nonlinear Dynamics and Chaos with applications to Physics, Biology, Chemistry & Engineering, 2nd Edition, Westview Press 2014.

H. D. I. Abarbanel, Analysis of Observed Chaotic Data, Springer 1997.

R. C. Hilborn, Chaos and Nonlinear Dynamics: An Introduction for Scientists and Engineers, Oxford University Press 1994.
R. H. Shumway and D. S. Stoffer, Time Series Analysis and Its Applications, 3rd Edition, Springer 2011.
D. Sornette, Critical Phenomena in Natural Sciences, Springer 2000.
M. Cross and H. Greenside, Pattern Formation and Dynamics in Non-equilibrium Systems, Cambridge University Press 2009.
R. P. Sattoras, M. Rubi and A. D. Guilera (Eds), Statistical Mechanics of Complex Networks, Springer 2003.

Evaluation Pattern

Assessment component	**Type of Assessment**	**Minimum Number of Assessments**	**Weightage (%)**
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS710	**Multiscale Fluid Modelling**	**L-T-P-C: 2-0-1-3**

Course Objectives

- Impart the understanding of important concepts of continuum fluid mechanics and related modeling and computational methods.
- Introduce various particle-based fluid models in the context of game physics and fluid animation.
- Equip with the skills and tools essential for applied computational and data driven modelling in fluid dynamics.

Course Outcomes

After completing this course, the students will be able to,

- **CO1:** Develop working knowledge of various computational and data driven fluid models.
- **CO2:** Apply the knowledge of data driven and computational methods to real world fluid problems and fluid animations.
- **CO3:** Contribute to the development of applied computational and data driven fluid mechanics.

CO-PO Mapping

PO/PSO							**PSO1**	**PSO2**	**PSO3**	**PSO4**

CO	PO1	PO2	PO3	PO4	PO5	PO6				
CO1	2	1	--	--	--	1	3	2	2	-
CO2	2	3	3	1	2	3	-	2	2	3
CO3	1	3	3	3	3	3	-	2	2	2

Syllabus

Macroscopic fluid modeling: Continuum, Reynolds Transport Theorem, Continuity equation, Navier-Stokes Equation, Discretization schemes and numerical solution to partial differential equations, Flow over a cylinder and von Karman vortex street, Reynolds averaged Navier-Stokes Equations, Introduction to machine learning in fluid mechanics, Introduction to deep learning for turbulence, fluid dynamics and control. Mesoscopic and microscopic fluid modelling: Introduction to particle fluid models for game physics and animation, Lattice gas automata and Lattice-Boltzmann methods, Machine learning applied to particle methods of fluid modelling.

Textbook / References

Som, SK., Biswas, G. and Chakraborty, S., Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw-Hill Education, 2003.

Bridson, R., Fluid simulation for computer graphics, CRC Press, Taylor and Francis, 2015.

Wolf-Gladrow DA. Lattice-gas cellular automata and lattice Boltzmann models: an introduction. Springer; 2004.

Various research publications.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS704	Deep Learning for Speech Signal Processing	L-T-P-C: 2-0-1-3

Course Objectives

- To develop an understanding on the acoustics of speech production.
- To analyze the time-domain and frequency domain features of speech signal.
- To develop an understanding on the deep learning based end-to-end speech processing.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand the acoustics of speech signal production and its characteristics.
- **CO2:** Analyze the time-domain and frequency domain features of speech signal.
- **CO3:** Understand and practice various parts of the deep learning based end-to-end speech processing pipeline.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	2	3	-	-	2	-
CO2	3	2	3	2	2	3	2	3	2	-
CO3	3	3	3	2	3	3	-	2	2	3

Syllabus

Human Speech Production System, Speech Signal Characteristics, Classification of sound units and its properties. Short-term processing of speech- Time Domain and Frequency domain parameters, Spectrograms, Cepstral Analysis, MFCC, Linear Prediction Analysis, Speech Recognition- GMM, HMM models, Deep Neural Network models, End-to-end Speech Recognition (Wav2letter, DeepSpeech, Jasper), End-to-end Speech Synthesis (WaveNet, Tacotron). End-to-end Speech Classification- Speaker Verification, Speaker Diarization, Other speech technology applications (such as Source Separation, Speech Pathology Detection).

Textbook / References

L. Rabiner, Biing-Hwang Juang and B. Yegnanarayana,"Fundamentals of Speech Recognition" Pearson Education Inc.2009

Thomas F Quatieri,"Discrete Time Speech Signal Processing", Pearson Education Inc.,2004

Kamath, Uday, John Liu, and James Whitaker. Deep learning for NLP and speech recognition. Vol. 84. Cham: Springer, 2019.

Hannun, Awni, et al. "Deep speech: Scaling up end-to-end speech recognition." arXiv preprint arXiv:1412.5567 (2014).

Collobert, Ronan, Christian Puhrsch, and Gabriel Synnaeve. "Wav2letter: an end-to-end convnet-based speech recognition system." arXiv preprint arXiv:1609.03193 (2016).

Shen, Jonathan, et al. "Natural TTS synthesis by conditioning wavenet on mel spectrogram predictions." 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE, 2018.

Kuchaiev, Oleksii, et al. "Mixed-precision training for NLP and speech recognition with openseq2seq." arXiv preprint arXiv:1805.10387 (2018).

Li, Jason, et al. "Jasper: An end-to-end convolutional neural acoustic model." arXiv preprint arXiv:1904.03288 (2019).

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS705	Social Media Analytics	L-T-P-C: 2-0-1-3

Course Objectives

- To understand and apply key concepts in social media metrics.
- To monitor consumers and competitors and mine deeper consumer insights based on advanced social media data modeling.
- To understand and apply key concepts in social media analytics tools and metrics.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Use different methods for collecting, analyzing, and exploring social media data.
- **CO2:** Build data driven models for solving social media problems.
- **CO3:** Analyze the social media networks to glean new insights

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	3	3	2	-	-	2	2
CO2	3	3	3	2	3	3	2	3	2	2
CO3	3	3	3	3	3	3	-	-	2	3

Syllabus

Introduction to Social Media Analytics - Network fundamentals and models - Collecting Social Media Data - Monitoring Customer Engagement in social media - Fundamentals of Social Data Analytics - Social Network Analysis and Metrics - Identifying Influencers in Social Network - Applied Social Data Analytics

Textbook / References

Szabo, G., G. Polatkan, O. Boykin and A. Chalkiopoulus," Social Media Data Mining and Analytics " Wiley, ISBN 978-1-118-82485-6.2019

Matthew A. Russell," Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More", O'Reilly Media.,2013

Finger, L. and Dutta, S. " Ask, Measure, Learn: Using Social Media Analytics to Understand and Influence Customer Behavior", O'Reilly. 2019.

David Easley and Jon Kleinberg. " Networks, Crowds, and Markets: Reasoning About a Highly Connected World", Cambridge University Press. 2010.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS703	Deep Learning for Biomedical Data Analysis	L-T-P-C: 2-1-0-3

Course Objectives

- This course provides the state-of-the-art deep learning algorithms applied in biomedical data analysis.
- This course provides the practical skills required to implement the state-of-the-art deep learning algorithms for biomedical image segmentation.
- This course provides the basics of deep generative models for biomedical image analysis.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** To understand the fundamentals of state-of-the-art deep learning algorithms applied in biomedical data analysis.
- **CO2:** To implement state-of-the-art deep learning algorithms for biomedical data analysis.
- **CO3:** To implement Generative Adversarial Networks for data augmentation.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	2	2	3	-	2	2
CO2	3	3	3	2	3	3	-	3	2	2
CO3	3	3	3	2	3	3	-	3	2	2

Syllabus

Introduction to ECG, EEG, MRI and CT datasets – Hybrid Deep Learning Models for ECG Signal classification – Federated Transfer Learning for EEG Signal Classification - Benchmark Deep Learning Algorithms for Biomedical Image Segmentation: SwinUNet : UNet like Pure Transformer – FANet : Feedback Attention Network – MedT: Medical Transformer – Generative Adversarial Network for Synthetic Data Augmentation.

Textbook / References

Goodfellow I, Bengio Y, Courville A, & Bengio Y, "Deep learning", Cambridge: MIT Press, 1st Edition, 2016.

Michael Nielsen, "Neural Networks and Deep Learning", Goodreads (eBook), 2013.

Bengio Y, "Learning Deep Architectures for AI, Foundations and Trends in Machine Learning", nowpublishers, 2009.

Weblink: https://paperswithcode.com/task/ecg-classification .

Weblink: https://paperswithcode.com/task/eeg .

Weblink: https://paperswithcode.com/task/medical-image-segmentation .

Weblink: https://github.com/xinario/awesome-gan-for-medical-imaging .

Evaluation Pattern

Assessment component	**Type of Assessment**	**Minimum Number of Assessments**	**Weightage (%)**
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS706	**Deep Learning for Visual Recognition**	**L-T-P-C: 2-1-0-3**

Course Objectives

- This course provides the state-of-the-art deep learning algorithms applied in visual recognition tasks.
- This course provides the practical skills required to implement the state-of-the-art deep learning algorithms for object detection and segmentation.
- This course provides the basics of deep generative models.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** To understand the fundamentals of state-of-the-art deep learning algorithms applied in visual recognition.
- **CO2:** To implement state-of-the-art deep learning algorithms for object detection.

- **CO3:** To implement state-of-the-art deep learning algorithms for image segmentation.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	2	2	3	-	2	2
CO2	3	3	3	2	3	3	-	3	2	2
CO3	3	3	3	2	3	3	-	3	2	2

Syllabus

Evolution of convolutional neural networks (CNN's): Inception, Exception, Resnet, EfficientNet - CNNs for Recognition and Verification: Siamese Networks – CNNs for Object Detection: R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD, RetinaNet – CNNs for Segmentation: FCN, SegNet, U-Net, Mask-RCNN – Introduction to Deep Generative Models.

Textbook / References

Goodfellow I, Bengio Y, Courville A, & Bengio Y, "Deep learning", Cambridge: MIT Press, 1st Edition, 2016.

Michael Nielsen, "Neural Networks and Deep Learning", Goodreads (eBook), 2013.

Bengio Y, "Learning Deep Architectures for AI, Foundations and Trends in Machine Learning", nowpublishers, 2009.

Evaluation Pattern

Assessment component	**Type of Assessment**	**Minimum Number of Assessments**	**Weightage (%)**
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS707	**Deep Learning for Cyber Security**	**L-T-P-C: 3-0-3-4**

Course Objectives

- This course provides the basic concepts of deep learning and cyber security.
- This course provides the implementation of deep learning algorithms in cyber security related problems.
- This provides ways to create tools related to cyber security using deep learning models.

Course Outcomes

After completing this course, the students will be able to

- **CO1:** To understand the concepts behind deep learning and cyber security.
- **CO2:** To implement deep learning algorithms in cyber security related problems.
- **CO3:** To create tools related to cyber security using deep learning models.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	3	3	3	-	2	2
CO2	3	3	3	2	3	3	-	3	2	2
CO3	3	2	2	2	2	3	-	3	2	2

Syllabus

Basic deep learning concepts, Introduction to Cyber Security, vulnerabilities, risks, cyber threats, cyber security safeguards - access control, audit, authentication, cryptography, denial-of-service, firewalls, spam email detection, intrusion detection, intrusion prevention, malware attacks and counter measures, malicious URL detection.

Textbook / References

Carl Enrolf, Eugene Schultz, Jim Mellander, "Intrusion detection and Prevention", McGraw Hill, 2004

Dowd, Mark, John McDonald, and Justin Schuh. The art of software security assessment: Identifying and preventing software vulnerabilities. Pearson Education, 2006

Sumeet Dua and Xian Du, Data Mining and Machine learning in Cybersecurity, CRC Press, 2011.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS711	Computer Vision	L-T-P-C: 2-1-0-3

Course Objectives

- To introduce students to the state-of-the-art algorithms in the area of image analysis and object recognition
- Give an exposure to video analysis techniques for object tracking and motion estimation
- To build good understanding on the computer vision concepts and techniques to be applied for robotic vision applications
- Enable students to apply the vision algorithms and develop applications in the domain of image analysis, robotic navigation

Course Outcomes

After completing this course, the students will be able to

- **CO1:** To build an understanding on detailed models of image formation
- **CO2:** To expose the students to techniques of image analysis through image feature extraction and object recognition
- **CO3:** To introduce fundamental algorithms for video analysis such as object tracking, motion segmentation etc
- **CO4:** Become familiar with the major technical approaches involved in image registration, camera calibration, pose estimation, stereo vision etc to be applied to develop vision algorithms for robotic applications.
- **CO5:** Apply the algorithms and develop applications in the domain of image analysis and robotic vision

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	-	-	-	-	-	2	-
CO2	3	2	-	-	1	-	-	2	2	2
CO3	3	3	2	-	-	-	2	-	2	-
CO4	-	-	3	1	2	-	-	-	2	-
CO5	- -	-	-	3	3	-	-	2	2	3

Syllabus

Introduction to Image Processing-Basic mathematical concepts: Image enhancement: Grey level transforms, Spatial ltering. Extraction of special features: edge and corner detection. Morphological processing, Image transforms, Discrete Fourier Transform, Fast Fourier Transform. Frequency domain enhancement.

Image Segmentation Algorithms: contextual, non-contextual segmentation, texture segmentation. Feature Detectors and Descriptors, Feature Matching-Object Recognition, Face detection (Viola Jones), Face Recognition.

Modern computer vision architectures based on deep convolutional neural networks, The Use of Motion in Segmentation Optical Flow & Tracking Algorithms, YOLO, DeepSORT: Deep Learning to Track Custom Objects in a Video, Action classification with convolutional neural networks, RNN, LSTM

Image registration, 2D and 3D feature-based alignment, Pose estimation, Geometric intrinsic calibration, - Camera Models and Calibration: Camera Projection Models - Projective Geometry, transformation of 2-d and 3-d, Internal Parameters, Lens Distortion Models, Calibration Methods Geometry of Multiple views-Stereopsis, Camera and Epipolar Geometry, Fundamental matrix; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration., Introduction to SLAM (Simultaneous Localization and Mapping).

Textbook / References

Deep Learning (Adaptive Computation and Machine Learning series) Ian Goodfellow, Yoshua Bengio, Aaron Courville, Francis Bach, January 2017, MIT Press

Introduction to Computer Vision and its Application, Richard Szelinski,2010

E. Trucco and A. Verri, Prentice Hall, 1998.Introductory techniques for 3D Computer Vision.

Marco Treiber, \An Introduction to Object Recognition Selected Algorithms for a Wide Variety of Applications", Springer, 2010.

Forsyth and Ponce, \Computer Vision {A Modern Approach", Second Edition, Prentice Hall, 2011.

R. C. Gonzalez, R. E. Woods, 'Digital Image Processing', 4th edition Addison-Wesley,2016.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS712	Reinforcement Learning	L-T-P-C: 2-1-0-3

Course Objectives

- Learn how to define RL tasks and the core principals behind the RL
- Understand and work with approximate solutions (deep Q network-based algorithms)
- Explore imitation learning tasks and solutions

- Recognize current advanced techniques and applications in RL

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand the relevance of Reinforcement Learning and how does it complement other ML techniques.
- **CO2:** Understand various RL algorithms
- **CO3:** Formulate a problem as a Reinforcement Learning problem and solve it
- **CO4:** Implement RL algorithms

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	1	2	1	-	-	-	-	2	2
CO2	3	1	2	1	-	-	3	-	2	2
CO3	-	3	2	3	3	-	-	-	3	3
CO4	3	3	3	3	-	-	-	3	3	3

Syllabus

Reinforcement learning vs all, multi-armed bandit, Decision process & applications, Markov Decision Process, Cross entropy method, Approximate cross entropy method, approximate cross entropy method, Evolution strategies: core idea, math problems, log-derivative trick, duct tape. Blackbox optimization: drawback **-** Dynamic Programming, Reward design, state and Action Value Functions, Measuring Policy Optimality, Policy: evaluation & improvement, Policy and value iteration, Model-free methods: Model-based vs model-free, Monte-Carlo & Temporal Difference; Q-learning, Exploration vs Exploitation, Footnote: Monte-Carlo vs Temporal Difference, Accounting for exploration. Expected Value SARSA, On-policy vs off-policy; Experience replay. Approximate Value Based Methods: Supervised & Reinforcement Learning, Loss functions in value based RL, difficulties with Approximate Methods, DQN – bird's eye view, DQN – the internals, DQN: statistical issues, Double Q-learning, More DQN tricks, Partial observability.

Textbooks / References

Sutton and Barto, Reinforcement Learning: An Introduction, 2nd Edition. MIT Press, Cambridge, MA, 2018

Csaba Szepesvári, Algorithms for Reinforcement Learning, Morgan & Claypool. 2010.

Marco Wiering and Martijn van Otterlo, Reinforcement Learning: State-of-the-Art Adaptation, Learning, and Optimization, Springer, 2012.

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS713	Blockchain Technology	L-T-P-C: 2-1-0-3

Course Objectives

- Understand how blockchain systems (mainly Bitcoin and Ethereum) work
- To securely interact with them
- Design, build, and deploy smart contracts and distributed applications
- Integrate ideas from blockchain technology into their own projects

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand the concepts of cryptocurrency, blockchain, and distributed ledger technologies
- **CO2:** Analyse the application and impact of blockchain technology in the financial industry and other industries
- **CO3:** Evaluate security issues relating to blockchain and cryptocurrency
- **CO4:** Design and analyze the impact of blockchain technology

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	1	1	1	2	-	2	2
CO2	2	2	3	2	2	2	-	-	2	3
CO3	3	3	3	3	3	3	-	3	2	3
CO4	2	2	2	3	3	1	-	3	2	3

Syllabus

History, definition, features, types, and benefits of block chain and bitcoin, Consensus, CAP theorem and blockchain. Decentralization – methods, routes, smart contracts, platforms. Symmetric and Asymmetric cryptography - Public and private keys, theoretical foundations cryptography with practical examples. Introduction to financial markets, use cases for block chain technology in the financial sector. Bitcoin, Transactions, Block chain, Bitcoin payments, technical concepts related to bitcoin cryptocurrency. Smart Contracts, definition of smart contracts, Ricardian contracts, Oracles, and the theoretical aspects of smart contracts. Ethereum 101 - design and architecture of the Ethereum block chain, Various technical concepts related to the Ethereum block chain that explains the underlying principles, features, and components of this platform in depth. Hyperledger – protocol and architecture. Case studies on alternative Blockchains.

Textbooks / References

mran Bashir, Mastering Blockchain - Distributed ledgers, decentralization and smart contracts explained, Packt Publishing Ltd, Second Edition, ISBN 978-1- 78712-544-5, 2017

Andreas Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, O'Reilly Publishing 2014 978-0691171692

Daniel Drescher, Blockchain Basics: A Non-Technical Introduction in 25 Steps, Apress, First Edition, 2017

Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction. Princeton University Press (July 19, 2016)

William Mougayar. The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology. Wiley; 1st edition (May 9, 2016)

Bitcoin: A Peer-toPeer Electronic Cash System Satoshi Nakamoto Online 2009https://bitcoin.org/bitcoin.pdf

VitalikButerinEthereum White Paper Online 2017https://github.com/ethereum/wiki/wiki/WhitePaper

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS714	Predictive Analytics for Internet of Things	L-T-P-C: 2-1-0-3

Course Objectives

- The course will help to apply machine learning concepts to the IoT data
- Choose appropriate machine learning models for analyzing IoT applications
- To integrate the deep learning scenario to the predictive models
- To visualize IoT data and identify target variables using appropriate algorithms

Course Outcomes

After completing this course, the students will be able to

- **CO1:** To study the protocols and communication models used in IoT
- **CO2:** To learn and understand the data analysis concept related to IoT
- **CO3:** To have a working knowledge of the platforms used for analyzing the cloud data
- **CO4:** To understand the Big Data technologies and to apply analytics concepts to Industrial problems
- **CO5:** To create a dashboard for data visualization and performing analysis for geo-spatial databases

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	1	1	1	-	2	2	2
CO2	3	3	3	2	2	1	2	-	2	2
CO3	2	2	2	2	3	1	-	3	2	3
CO4	2	2	2	2	3	3	-	3	2	3
CO5	3	2	3	2	3	3	-	2	2	3

Syllabus

Introduction to IoT - Definitions, frameworks and key technologies. Challenges to solve in IoT - Key hardware and software elements. Applications: smart transportation, smart cities, smart living, smart energy, smart health, and smart learning. Real-World Data representation and visualization, Introduction to Data Analytics for IoT.

IoT Analytics- Definition, Challenges, Devices, Connectivity protocols, data messaging protocols- MQTT, HTTP, CoAP, Data Distribution Services (DDS), IoT Data Analytics – Elastics Analytics Concepts, Scaling.

Cloud Analytics and Security, AWS / Azure / ThingWorx. Design of data processing for analytics, application of big data technology to storage, Exploring and visualizing data, solution for industry specific analysis problem.

Visualization and Dashboard – Designing visual analysis for IoT data- creating dashboard –creating and visualizing alerts – basics of geo-spatial analytics- vector based methods-raster based methods- storage of geo-spatial data - processing of geo spatial data- Anomaly detection forecasting. case study: pollution reporting problem.

Textbooks / References

Vijay Madisetti and ArshdeepBahga, "Internet of Things: A Hands-on Approach", Hardcover – Import, 2014.

Andrew Minteer, Analytics for Internet of Things, Packt Publications Mumbai 2017

Kai Hwang, Min Chen, Big Data Analytics for Cloud, IoT and Cognitive Computing Hardcover, 2017

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20

21DS715	Cloud Computing and Security in the Cloud	L-T-P-C: 2-1-0-3

Course Objectives

- To gain in-depth knowledge of Cloud Computing concepts, technologies, architecture and applications by introducing and researching state-of-the-art in Cloud Computing fundamental issues, technologies, applications and implementations.
- To expose the students to frontier areas of Cloud Computing and information systems, while providing sufficient foundations to enable further study and research.
- To learn the current security standards, protocols, and best practices intended for delivering Cloud based enterprise services

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand the basic principles of cloud computing
- **CO2:** Analyze the Cloud computing setup with it's vulnerabilities and applications using different architectures
- **CO3:** Assess cloud Storage systems and Cloud security, the risks involved, its impact and develop cloud application
- **CO4:** Understand the various data security and storage algorithms
- **CO5:** Assess the strengths and weaknesses of various algorithms used in cloud security

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	1	2	1	-	-	-	2	2	-
CO2	3	1	2	1	-	-	-	3	2	-
CO3	-	3	2	3	3	-	-	3	2	2
CO4	3	3	3	3	-	-	2	-	2	-
CO5	2	2	1	2	2		2	3	2	-

Syllabus

Introduction to cloud computing – Evolution of cloud computing, definition of cloud computing, SPI framework, Service delivery model, Deployment models, Key drivers to adopting the cloud, Barriers to cloud computing adoption in the cloud, Modular arithmetic background, concepts of security, how to assess security of a system, information theoretic security v/s computational security, Data security and storage in cloud, data dispersal techniques, High-availability and integrity layer for cloud storage, Encryption and key management in the cloud, Cloud forensics, Data location and availability, Data security tools and techniques for the cloud, Data distribution and information dispersal techniques, Data encryption/decryption methodologies and algorithms for a client-server setup such as SSL, IPSec, etc., Introduction to Homomorphic encryption. Approximate string searching over encrypted data stored in the cloud, Trustworthy cloud infrastructures, Secure computations, cloud related regulatory and compliance issues.

Textbooks / References

Zeal Vors, "Enterprise Cloud Security and Governance: Efficiently set data protection and privacy principles", First Edition, 2017.

Tim Mather, S. Kumaraswamy and S.Latif, "Cloud Security and Privacy: An Enterprise Perspective on Risks and compliance", O'Reilly Media, 2009

William Stallings, "Cryptography and Network Security: Principles and Practice, Fifth Edition, Prentice Hall, 2011.

William Stallings, Lawrie Brown, "Computer Security: Principles and Practice", Pearson, 2012.

Menezes. A, Oorschot. P, and Vanstone. S, Handbook of Applied Cryptography, CRC Press, 1996

B. Schneier, "Applied Cryptography: Protocols, Algorithms, and source Code in C", Second Edition, Jhon Wiley and Sons, 1996.

John Sammons, "The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics", second edition, 2014.
Terrence Lillard, "Digital Forensics for Network, Internet, and Cloud Computing, Elsevier, 2010.

Evaluation Pattern

Assessment component	**Type of Assessment**	**Minimum Number of Assessments**	**Weightage (%)**
Internal	Quizzes, Assignments, Presentations	8 (each worth 10%)	80
External	Term Project	1	20