Amrita School of Computing
Amrita Vishwa Vidyapeetham

M.TECH DATA SCIENCE
CURRICULUM 2024

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 program aims at preparing students in data science especially in data driven modeling and scientific computation. This program is tuned to cater to the demands in terms of skills required for the emerging scenarios in the industry and academia. Students will be skilled in domains such as Automation, Deep Learning, Text Analytics, Generative AI and System Building.

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 Specific Objectives (PSOs)

Graduates of the program will be able to

PSO1: Apply the mathematical concepts and techniques of data science to formulate solutions of real-world problems in industry relevant domains

PSO2: Implement the algorithms for solving problems related to data science using high performance computing platform and cloud computing platform.

PSO3: Conduct research in data science and pursue a career in research and development pertinent to data science.

SEMESTER I

Category	Course Code	Title	L-T-P	Credit
FC	24MA604	Computational Mathematics for Data Science	3 0 3	4
FC	24DS601	Machine Learning	3 0 3	4
FC	24DS602	Foundation of Data Management	3 0 3	4
SC		SC-1	2 0 3	3
HU	22AVP103	Mastery Over Mind (MAOM)	1 0 2	2
SC	24RM607	Research Methodology	2 0 0	2
HU	23AVP601	Amrita Values Program		P/F
HU	23HU601	Career Competency - I	0 0 3	P/F
		Total	30	19

SEMESTER II

Category	Course Code	Title	L-T-P	Credit
FC	24DS611	Deep Learning	3 0 3	4
SC		SC-2	2 0 3	3
SC		SC-3	2 0 3	3
SC		SC-4	2 0 3	3
E		Elective 1	2 0 3	3
E		Elective 2	2 0 3	3
HU	23HU611	Career Competency - II	0 0 3	1
		Total	34	20

SEMESTER III

Category	Course Code	Title	L-T-P	Credit
E		Elective 3	2 0 3	3
E		Elective 4	2 0 3	3
P	24DS798	Dissertation	0 0 11	11
		Total	21	17

SEMESTER IV

Category	Course Code	Title	L-T-P	Credit
P	24DS799	Dissertation	0 0 16	16
		Total	16	16
		Grand Total		72

LIST OF COURSES

FOUNDATION CORE

Course Code	Title	L-T-P	Credit
24MA604	Computational Mathematical for Data Science	3 0 3	4
24DS602	Foundation of Data Management	3 0 3	4
24DS601	Machine Learning	3 0 3	4
24DS611	Deep Learning	3 0 3	4

SUBJECT CORE

Course Code	**Title**	**L-T-P**	**Credit**
24DS631	Embedded Computing & Realtime OS for Data Science Applications	2 0 3	3
24RM607	Research Methodology	2 0 0	2
24DS632	Introduction to Probabilistic Graphical Models	2 0 3	3
24DS633	Scientific Computing	2 0 3	3
24DS634	Text Mining and Analytics	2 0 3	3
24DS635	Big Data Framework for Data Science	2 0 3	3
24DS636	Statistical Modelling	2 0 3	3
24DS637	Advanced Data Visualization and Analytics	2 0 3	3

PROFESSIONAL ELECTIVES

Course Code	Title	L-T-P	Credit
24DS731	AI Applications for Power Systems	2 0 3	3
24DS732	Deep Learning in Genomics and Biomedicine	2 0 3	3
24DS733	Deep Learning for Biomedical Data Analysis	2 0 3	3
24DS734	Deep Learning for Speech Signal Processing	2 0 3	3
24DS735	Social Media Analytics	2 0 3	3
24DS736	Deep Learning for Visual Recognition	2 0 3	3
24DS737	Deep Learning for Cyber Security	2 0 3	3
24DS738	Complex Systems in Engineering, Finance & Biology: Modelling & Analysis	2 0 3	3
24DS739	High Performance Computing	2 0 3	3
24DS740	Multiscale Modelling in Fluid Mechanics	2 0 3	3
24DS741	Computer Vision	2 0 3	3
24DS742	Reinforcement Learning	2 0 3	3
24DS743	Blockchain Technology	2 0 3	3
24DS744	Predictive Analytics for Internet of Things	2 0 3	3
24DS745	Cloud Computing and Security in the Cloud	2 0 3	3
24DS746	Financial Data Analytics	2 0 3	3
24DS747	Material Informatics	2 0 3	3
24DS748	Integration of data science and system biology	2 0 3	3
24DS749	Introduction to Graph Theory	2 0 3	3

SEMESTER I

24MA604	Computational Mathematical for Data Science	L-T-P-C: 3-0-3-4

Course Objectives

- The course will lay down the basic concepts and techniques of linear algebra, calculus and optimization theory 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 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: Use computational techniques and algebraic skills essential for the study of systems of linear equations, matrix algebra, vector spaces, eigenvalues and eigenvectors, orthogonality, diagonalization, matrix projection.

CO2: understand the importance of single variable calculus and multivariable calculus in machine learning models.

CO3: Understand the importance of optimization for data science and implementation of analytical & numerical methods for solving constrained optimization problems and unconstrained optimization problems.

CO4: Understand the use of linear algebra, calculus and optimization techniques in various algorithm formulation in data science using machine learning, deep learning and reinforcement learning techniques.

CO-PO Mapping

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

Syllabus

Matrices, Rank, and Gaussian Elimination-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- Gram Schmidt orthogonalization, Eigenvalues and Eigenvectors – Singular

Value Decomposition, diagonal form of a matrix, Positive Definite Matrices - minima, maxima and saddle points, tests for positive definiteness, semi-definite and indefinite matrices.

Introduction -Single Variable calculus and multi-variable calculus

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, unconstrained minimization- gradient descent method, Conjugate gradient method, steepest descent method, Newton's method.

Textbooks / 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.*
- *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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS601	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 implement data pre-processing for usage in Machine Learning algorithms
- **CO2:** To learn and implement supervised Machine Learning algorithms
- **CO3:** To learn and implement unsupervised Machine Learning algorithms
- **CO4:** To learn and evaluate the machine learning model's performances.

CO-PO Mapping

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

Syllabus

Foundations of machine learning: Regression Vs. Classification, Generalization, Training, Validation and Testing, Problem of Overfitting and mechanisms to overcome overfitting, Bias Vs. Variance, vector independence, matrices and vector spaces, probability recap – conditional and joint.

Data Handling: Datatypes and mathematical operations, scaling / normalization, binning & discretization, missing value imputation, encodings.

Supervised Learning: Classification algorithms – Support Vector Machines (SVM), Perceptron & Neural Networks, k-Near Neighbor (kNN) & weighted-kNN, Decision Trees (DT), Random Forest (RF), Boosting classifiers, Bayesian classifier & Naive-Bayes algorithm, Markov Model and HMM, Stacking classifiers; Regression algorithms – linear, logistic, kNN, Random Forest, SVM (Support Vector Machines); Clustering algorithms – partition algorithms, hierarchical algorithms.

Performance metrics: Classification, Regression & Clustering

Data Dimensionality – Curses of dimensionality, dimensionality reduction techniques.

Machine learning algorithms applied for signal and image analysis.

Textbooks / References

- *Tom Mitchell. Machine Learning. McGraw Hill; 2017*
- *Trevor Hastie, Robert Tibshirani, Jerome Friedman. The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Springer, 2017.*
- *Miroslav Kubat. An Introduction to Machine Learning. Springer, 2017.*
- *Christopher M Bishop. Pattern Recognition and Machine Learning. Springer, 2010.*
- *Richard O. Duda, Peter E. Hart, David G. Stork. Pattern Classification. Wiley, Second Edition, 2007.*
- *Kevin P. Murphey. Machine Learning, a probabilistic perspective. The MIT Press Cambridge, Massachusetts, 2012.*
- *Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar. Foundations of Machine Learning. The MIT Press, 2018.*
- *Lisa Tagliaferri, Michelle Morales, Ellie Birkbeck, Alvin Wan. Python Machine Learning Projects. DigitalOcean, 2019.*
- *Andrew Ng. Machine Learning Yearning Technical Strategy for AI Engineers, In the Era of Deep Learning. 2018.*
- *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.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS602	Foundations of Data Management	L-T-P-C: 3-0-3-4

Course Objectives

- This course aims to introduce the concepts of processing, storing, and retrieving data.
- This course will also familiarize students with fundamental data structures, information retrieval techniques, dimensionality reduction, and database management systems (DBMS)
- The students will be motivated to apply these concepts to address diverse engineering and research challenges.

Course Outcomes:

CO1: Choose an appropriate data structure as applied to a specified problem.
CO2: Acquire knowledge in standard database systems concepts such as tables, relations, and queries, then apply them to address research or engineering challenges
CO3: Ability to retrieval of information through techniques like indexing, scoring, and ranking.
CO4: Acquire techniques for reducing data dimensionality and eliminating noise.

CO-PO Mapping

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

Syllabus

Unit1: Data Analysis and Visualization Techniques
Data Collection: Various sources and types of data: text, video, audio, biology etc; Data *Preprocessing:* Cleaning data, missing data imputation, noise elimination, feature selection and dimensionality reduction (PCA, tSNE, UMAP), normalisation. *Data Visualization:* histogram, pie chart, area-plot, box plot, scatter-plot, bubble plot, waffle charts etc.

Unit2: Data Structure and Algorithm
Data Structure: Stack, Queue, Linked List, Graphs. *Algorithms*. Searching, Sorting, Graph traversal, Complexity (Time)

Unit3: Database Management System

Database, Schema, ER diagram, SQL (Postgresql), database normalization (1NF,2NF,3NF and BCNF), indexing (B+tree), transaction concept and simple transaction model, serializability concept, concurrency control

Textbooks / References

- *Introduction to Algorithms. Cormen, Leiserson, Rivest, Stein. MIT Press 3ed. ISBN-13: 978-0262533058*
- *2. Database System Concepts. Silberschatz, Korth, Sudarshan. McGraw Hill Education; Sixth edition. ISBN-13: 978-9332901384*
- *3. Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools. Cielen, Meysman,Ali. Dreamtech Press. ISBN-13: 978-9351199373*
- *References*
- *1. Data Engineering: A Novel Approach to Data Design. Brian Shive. Technics Publications. ISBN-13: 978-1935504603*
- *2. Python Data Science Handbook: Essential Tools for Working with Data. Joel Grus. O'Reilly. ISBN-13: 978-9352134915*
- *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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS631 Embedded Computing & RTOS for Data Science Applications L-T-P-C: 2-0-3-3

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:** To enable the student with the 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:** To work 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
CO1	3	2	2	2	2	2	-	3	1
CO2	3	3	2	2	2	2	-	3	2
CO3	3	3	3	3	3	2	-	3	2
CO4	3	2	2	3	3	2	3	3	2

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.

Textbooks / References

- *Amos, Brian, "Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools", Packt Publishing Ltd, 2020.*
- *Brian Amos, Jim Yuill, Penn Linder "Hands-On RTOS with Microcontrollers - Second Edition", Packt Publishing 2024.*
- *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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

SEMESTER II

24DS611	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:** Implement the basics of deep neural networks.
- **CO2:** Implement convolutional neural networks for data analysis.
- **CO3:** Implement sequential models for sequential data analysis.
- **CO4:** Apply transformers for solving real-world problems.

CO-PO Mapping

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

Syllabus

Perceptrons, Multilayer Perceptrons (MLPs), Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Backpropagation, Gradient Descent (GD), Stochastic GD, AdaGrad, RMSProp, Adam, Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Ensemble methods, Dropout, Better activation functions, Better weight initialization methods, Batch Normalization, Convolutional Neural Networks, Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Gated Recurrent Units (GRUs), Long Short Term Memory (LSTM) Cells, Encoder Decoder Models, Attention Mechanism, Transformers: Multi-headed Self Attention, Cross Attention.

Textbooks / 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.*
- *Charu C. Aggarwal, "Neural Networks and Deep Learning", Springer, 2nd Edition, 2019.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS632 Introduction to Probabilistic Graphical Models L-T-P-C: 2-0-3- 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: Develop probabilistic models for describing a given system

CO4: Analyse different probabilistic models developed for describing a given system.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	1	1	1	2	1	3	2	2
CO2	1	3	1	1	2	1	3	1	2
CO3	1	2	2	1	2	1	3	2	2
CO4	2	3	3	2	2	1	3	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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS634	Text Mining and Analytics	L-T-P-C: 2-0-3-3

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 tasks using Machine Learning/Deep Learning Model/LLM
CO3: Implement different deep learning models to solve real-time Text Analytics problems
CO4: Assess NLP models using various evaluation metrics and visualization

CO-PO Mapping

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

Syllabus

Introduction to Natural Language Processing -Words -N-grams -Language modelling - Part-of-Speech Tagging - Information Extraction-Name Entity Recognition and Relation Extraction. – Syntactic and Semantic Parsing – Morphological Analysis- Introduction of Nltk , SpaCy etc. tools for basic NLP task.

Text Representation and Transformation - Vector space models -Bag-of-Words -Term Frequency - Inverse Document Frequency - Word Vector representations: Word2vec, GloVe, FastText, BERT, AlBERT, Roberta– Word representation for Indic languages- IndicBERT, IndicFT, XLM, Muril- Topic Modelling-LDA,

Neural language models - Recurrent Neural Network - Long Short-Term Memory Networks - Encoder-decoder architecture - Attention mechanism - Transformer networks. Large Language Model (LLMs)-Zero short, few shots and Fine tuning of LLMs.

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

Textbooks / 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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS633	Scientific Computing	L-T-P-C: 2-0-3-3

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 mathematical models to describe natural/engineering/physical systems
- **CO2:** Solve the differential equations using numerical schemes
- **CO3:** Analyse the stability of systems using dynamical systems theory
- **CO4:** Develop data driven models of different engineering/natural/physical systems

CO-PO Mapping

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

Syllabus

Introduction to Mathematical Modelling, Linear system of equations, Eigenvalues and Eigenvectors, Stability of Systems using Eigen value analysis, 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, Data Driven Modelling, Dynamic mode decomposition, Koopman Theory, System Idenfication techniques for nonlinear systems, Physics Informed Neural Networks.

Textbooks / 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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS636	**Statistical Modeling**	**L-T-P-C: 2-0-3-3**

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: Apply the concepts of probability, conditional probability, independence, and Bayes' theorem, as well as the properties of discrete and continuous random variables and their distributions.
CO2: Apply and analyze parameter estimation and hypothesis testing techniques.
CO3: Implement various regression models and evaluate their performance in solving real-world problems.

CO4: Implement time-series models and evaluate their effectiveness in addressing real-world problems.

CO-PO Mapping

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

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, Hypothesis testing- Z, t, Chi-Square. 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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS637	Advanced Data Visualization and Analytics	L-T-P-C: 2-0-3-3

Course Objectives

- Develop proficiency in advanced visualization techniques, including interactive visualizations, 3D plots, network visualizations, and advanced chart types etc.
- This course will explore, visualize and analyze various types of data sets such as time series, geospatial and multimodal data.
- Gain practical experience with Python (Matplotlib, Seaborn, Plotly), JavaScript (D3.js), Tableau, and Power BI.

Course Outcomes

After completing this course, the students will be able to

CO1: Understand the importance of data visualization and interactive visualizations for diverse datasets.

CO2: Learn to create advanced visualization charts, interactive/animated dashboards and construct data stories and communicate important trends/patterns in the datasets.

CO3: Explore and Analyse Time series, Geospatial and multimodal data.

CO4: Acquire insights into the intersection of "Advanced data visualization and analytics" with AI.

CO-PO Mapping

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

CO2	3	2	3	1	2	1	2	3	3
CO3	2	3	2	1	3	1	2	3	3
CO4	2	2	2	2	2	1	2	3	3

Syllabus

Introduction to Data Visualization – Importance and benefits of good data visualization - Design principles - Introduction to python libraries for visualization: seaborn, plotly express, pygal – One dimensional (Pictogram, Pie chart, bar chart etc), two-dimentaional (scatterplot, histogram, ogive curve, line plot etc.) and chart based (Gantt Chart, Heat Map, Box and Whisker Plot, Waterfall Chart, Area Chart, Stacked Bar Charts etc) data visualization techniques - Color palettes – Creation of 3D Charts - Creation of Advanced Visualization: Heat Map– Facet Grid - Interaction Techniques: Manipulate View – Creation of interactive Network topologies and Treesmap – Dimentionality reduction – data cleaning

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, D3.js(Web-based Tools) - the principles of data storytelling and its importance in decision-making - techniques for structuring and presenting data-driven narratives - visual storytelling using data visualization tools - Interactive visualization techniques - Tools for Interactive Visualization - Designing Interactive Dashboards

PCA, t-SNE and UMAP. AI-powered data visualization and Exploratory Data Analysis (EDA) with AI.

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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS635	Bigdata Framework for Data Science	L-T-P-C: 2-0-3-3

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 tools for Bigdata manipulation.
CO4: Develop skills to handle and analyze large scale datasets.

CO-PO Mapping

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

Syllabus

Introduction to Bigdata - Characteristics of Big Data - Big Data Analytics - Typical Analytical Architecture - Challenges in Big Data Analytics - Need of big data frameworks.
Big data using Functional Programming in Scala - Loops, Lazy evaluation, Arrays, Strings and Collections, Classes and Objects, Functions, Recursion - Tail recursion, Higher Order Functions, Curried functions, Closures, Inheritance, Overloading and Overriding, Traits, Maps, Flatmaps, Sequence summations - Reduce, Fold, Scan, Filter.
Hadoop Framework - Hadoop - Requirement of Hadoop Framework - Design principle of Hadoop -Comparison with other system - Hadoop Components - Hadoop 1.0 vs Hadoop 2.0 vs Hadoop 3.0 - Hadoop Daemon's - HDFS Commands - Map Reduce Programming, Pipelining MapReduce jobs. Hadoop installation and programming.
Apache Spark Framework - Resilient Distributed Data Sets - Creating RDDs, Lineage and Fault tolerance, DAGs, Spark Programming, Application Execution, transformations and actions, persistence.
Setting up a standalone Spark cluster - spark-shell, basic API, Modules Core-Key/Value pairs and other RDD features, Data Frames and Datasets, Creating data frames from RDDs, Using Spark SQL to query data frames, NoSQL aggregate databases, MLlib examples on regression, classification and clustering problems, Analytics case studies.

Textbooks / References

- *Big Data: Principles and best practices of scalable realtime data systems by James Warren, Nathan Marz, 2015.*
- *Learning Spark: Lightning-Fast Big Data Analysis, 1st Edition by Holden Karau, Andy Konwinski, Patrick Wendell, 2015.*
- *Programming in Scala: A Comprehensive Step-by-Step Guide, 4th 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 Warren.*
- *Scala for the Impatient, 3rd Edition by Cay S. Horstmann*
- *Spark: The Definitive Guide: Big Data Processing Made Simple 1st Edition (Kindle Edition) by Bill Chambers, Matei Zaharia.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30

Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24RM607	**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**
CO1	1	-	-	3	1	1	-	-	3
CO2	-	-	-	1	2	3	-	-	3
CO3	-	-	-	-	2	3	-	-	3

Syllabus

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.

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.

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

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

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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

PROFESSIONAL ELECTIVES

24DS731	AI Applications for Power Systems	L-T-P-C: 2-0-3-3

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 Smart grid.
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
CO1	2	1	2	2	2	3	2	2	2
CO2	1	2	1	2	3	3	3	2	2
CO3	2	3	3	3	3	2	2	2	2

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.)

Textbooks / 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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS732	**Deep Learning in Genomics and Biomedicine**	**L-T-P-C: 2-0-3-3**

Course Objectives

- The course will lay down the basic concepts and techniques of Deep learning in Genomics and Biomedicine
- It examines how both deep learning and traditional machine learning models can be used to solve the key problems in Genomics and Biomedicine, contrasting and comparing their strengths and weaknesses.
- The goal of the course is to enable the students to apply the concepts and techniques of Deep learning in Genomics and Biomedicine.

Course Outcomes:

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

CO1: Develop an understanding of the basic concepts in Genomics and Biomedicine.
CO2: Use various feature representation schemes to represent Biomolecular and Genomics datasets.
CO3: Implement deep learning algorithms for Genomics data analysis.

CO4: Apply appropriate deep learning algorithms for Biomedicine and Drug Design.

CO-PO Mapping

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

Syllabus

Gene, Genome and Genomics - DNA, RNA and proteins, Transcription Factor (TF) binding, chromatin accessibility and RNA interference; protein sequence, protein structure and protein binding; Review of Machine Learning and Deep Learning - training, validation, regularization and hyperparameter optimization; Introduction to DeepChem library – prediction of toxicity of molecules; MoleculeNet – featurizing a molecule, SMILES strings and RDKit, ECFPs, molecular descriptors and graph convolutions; DenseNets and Convolutional Neural Networks (CNN) for Genomics, Recurrent Neural Networks (RNN); Autoencoders and representation learning; Variational autoencoders and Generative Models - generating new ideas for lead compounds, protein design, training a variational autoencoder to generate new molecules; Pretraining and Fine-tuning; Transformer-based models, BERT; One-shot Learning Drug Discovery - Case Studies.

Textbooks / References

- *Bharath Ramsundar, Peter Eastman, Patrick Walters, and Vijay Pande, "Deep Learning for the Life Sciences: Applying Deep Learning to Genomics, Microscopy, Drug Discovery, and More", O'Reilly Media, Inc. 2019.*
- *Sukumar, N., Anandaram, H., and Bhadra, P. "Computational Drug Discovery – A Primer" (Ion Cures Press, 2023). ISBN: 979-8850083663*
- *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.*
- *Vaswani, A., et al. "Attention Is All You Need." arXiv:1706.03762v5 [cs.CL] 6 Dec 2017*
- *Bagal, V., Aggarwal, R., Vinod, P. K. and U. Priyakumar, Deva, "MolGPT: Molecular Generation Using a Transformer-Decoder Model." J. Chem. Inf. Model. 2022, 62, 2064−2076 https://doi.org/10.1021/acs.jcim.1c00600*
- *ChemBERTa: Large-Scale Self-Supervised Pretraining for Molecular Property Prediction using a Smiles Tokenization Strategy.*

https://github.com/deepchem/deepchem/blob/master/examples/tutorials/Transfer_Learning_With_ChemBERTa_Transformers.ipynb

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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS739	**High Performance Computing**	**L-T-P-C: 2-0-3-3**

Course Objectives

- Familiarize students with HPC architecture, parallel programming and GPU architecture.
- To educate students on writing efficient parallel and GPU programming.
- To discuss various applications of HPC computational techniques in computational science.

Course Outcomes:

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

CO1: Understanding parallel computing involves grasping parallel architectures, programming models, and algorithms.

CO2: Design parallel programme and CUDA programme

CO3: Ability to analyze the performance of parallel programs.

CO4: Understand how combining HPC and AI is changing data science.

CO-PO Mapping

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

Syllabus

Introduction to High-Performance Computing (HPC), Architecture for parallel computing, Shared memory and distributed memory in parallel computing, Parallel algorithms, Performance metrics of parallel Systems, Introduction to OpenMP, Essential of OpenMP programming (matrix computing), Data sharing and synchronizing, Introduction to MPI and distributed memory parallel programming, Communication using MPI, Domain decomposition based parallelization of matrix solver, Introduction to CUDA, CUDA programming, thread execution in CUDA, matrix problem using CUDA.

Application HPC in data science (Big Data Analytics, AI, simulation, and modelling)

Textbooks / References

- *Georg Hager and Gerhard Wellein. Introduction to High Performance Computing for Scientists and Engineers (1st ed.). CRC Press, Chapman & Hall/CRC Computational Science, India, 2010.*
- *"High Performance Computing: Modern Systems and Practices" by Thomas Sterling and Matthew Anderson*
- *"CUDA by Example: An Introduction to General-Purpose GPU Programming" by Jason Sanders and Edward Kandrot*
- *"Parallel Programming with MPI" by Peter S. Pacheco*
- *Vipin Kumar , Ananth Grama , Anshul Gupta , George Karypis. Introduction to Parallel Computing (2nd ed.). Pearson India . 2003.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS738 Complex Systems in Engineering, Finance & Biology: Modelling & Analysis
L-T-P-C: 2-0-3-3

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
CO1	2	2	2	2	2	2	3	2	2
CO2	1	1	3	2	1	1	2	3	2
CO3	1	2	2	3	3	1	2	2	2

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.

General design principles of complex systems - autoregulation, feedforward and feedback loops. The human cell as a prototypical complex system; Network motifs in transcription, signal transduction and neuronal networks.

Modeling Complex Systems with AI - examples from climate science, financial modeling, systems biology and bioinformatics. Complex evolutionary and adaptive systems; Self-organizing collective systems; Biological computing for complex systems; AI in networks.

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.*
- *Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC Press, London, 2007.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS740	**Multiscale Modelling in Fluid Mechanics**	**L-T-P-C: 2-0-3-3**

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

Textbooks / 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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS734	Deep Learning for Speech Signal Processing	L-T-P-C: 2-0-3-3

Course Objectives

- To develop an understanding on the acoustics of speech production.
- To develop an understanding about the characteristics of speech signal
- 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: Analyse the acoustics of speech signal production
CO2: Differentiate the characteristics of speech signals
CO3: Analyze the time-domain and frequency domain features of speech signal.
CO4: 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
CO1	3	2	3	2	2	3	2	-	2
CO2	3	2	3	2	2	3	2	-	2
CO3	3	2	3	2	2	3	2	3	2
CO4	3	3	3	2	3	3	2	2	2

Syllabus

Human Speech Production System, Speech Signal Characteristics, Classification of sound units and its properties. Short-term p rocessing 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).

Textbooks / 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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS735	**Social Media Analytics**	**L-T-P-C: 2-0-3-3**

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.
- To understand and apply various evaluation metrics

Course Outcomes

After completing this course, the students will be able to

CO1: Apply different methods for collecting, analyzing, and exploring social media data.
CO2: Develop data driven models for solving social media problems.

CO3: Analyze the social media networks to glean new insights
CO4: Assess the various evaluation metrics related to social media networks

CO-PO Mapping

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

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 - Network dynamics, phase transitions in Networks - Identifying Influencers in Social Network - Applied Social Data Analytics.

Textbooks / 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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS733	Deep Learning for Biomedical Data Analysis	L-T-P-C: 2-0-3-3

Course Objectives

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

Course Outcomes

After completing this course, the students will be able to

- **CO1:** Understand the fundamentals of state-of-the-art deep learning algorithms applied in biomedical data analysis.
- **CO2:** Apply deep learning algorithms for extracting clean information from microscopy and radiology data.
- **CO3:** Implement state-of-the-art deep learning algorithms for biomedical data analysis.
- **CO4:** Implement Generative Adversarial Networks for data augmentation.

CO-PO Mapping

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

Syllabus

Introduction to ECG, EEG, MRI and CT datasets – Hybrid Deep Learning Models for ECG Signal classification – Federated Transfer Learning for EEG Signal Classification; Introduction to microscopy, diffraction limit, modern optical microscopy, super-resolution microscopy and fluorescence microscopy; Deep learning applications in microscopy – cell counting, cell segmentation; Computer-aided probabilistic diagnoses with Bayesian Networks, deep radiology; 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.

Textbooks / 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.*
- *Krull, A., Buchholz, T.-O., and Jug, F. (2019). "Noise2void–learning denoising from single noisy images," in Conference on Computer Vision and Pattern Recognition (CVPR) (Long Beach, CA), 2129–2137.*
- *Krull, A., Vic˘ar, T., Prakash, M., Lalit M. and Jug, F. (2020). Probabilistic Noise2Void:Unsupervised Content-Aware Denoising.*

https://www.frontiersin.org/articles/10.3389/fcomp.2020.00005

Weblink: https://github.com/juglab/n2v

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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS736	**Deep Learning for Visual Recognition**	**L-T-P-C: 2-0-3-3**

Course Objectives

- This course provides 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 implement the basics of state-of-the-art deep learning algorithms applied in visual recognition.
- **CO2:** To implement transfer learning methods for image analysis.
- **CO3:** To implement state-of-the-art deep learning algorithms for object detection.
- **CO4:** 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
CO1	3	3	3	2	3	3	2	3	2
CO2	3	3	3	2	3	3	2	3	2
CO3	3	3	3	2	3	3	2	3	2
CO4	3	3	3	2	3	3	2	3	2

Syllabus

Basics of Deep Neural Networks, Evolution of convolutional neural networks (CNN's): Inception, Exception, Resnet, EfficientNet – Transfer Learning– CNNs for Object Detection: R-CNN, Fast R-CNN, Faster R-CNN, YOLO, RetinaNet – U-Net for Image Segmentation – Vision Transformer – Visualizing CNN's - Introduction to Deep Generative Models – Self Supervised Contrastive Learning.

Textbooks / 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", now publishers, 2009.*
- *Zeiler, Matthew D., and Rob Fergus. "Visualizing and understanding convolutional networks." In Computer Vision–ECCV 2014: 13th European Conference, Zurich, Switzerland, September 6-12, 2014, Proceedings, Part I 13, pp. 818-833. Springer International Publishing, 2014.*
- *Dosovitskiy, Alexey, et al. "An image is worth 16x16 words: Transformers for image recognition at scale." arXiv preprint arXiv:2010.11929 (2020).*

- *Chen, Ting, Simon Kornblith, Mohammad Norouzi, and Geoffrey Hinton. "A simple framework for contrastive learning of visual representations." In International conference on machine learning, pp. 1597-1607. PMLR, 2020.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS737	**Deep Learning for Cyber Security**	**L-T-P-C: 2-0-3-3**

Course Objectives

- To understand the basic concepts of deep learning and cyber security.
- To implement deep learning algorithms in cyber security related problems.
- 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 and implement the concepts behind deep learning and cyber security.

CO2: To apply deep learning techniques for malware analysis and detection.

CO3: To understand how deep learning can be used for intrusion detection and anomaly detection.

CO4: To implement deep learning algorithms in cyber security related problems.

CO-PO Mapping

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

CO4	3	3	3	3	3	3	2	3	2

Syllabus

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.

Trends in AI for Cyber Security, Applications of ML/DL in Cyber Security, Supervised Learning- CNN & RNN for Cyber Security, Identification of Phishing Websites using DNNs, Unsupervised Learning in Neural Networks, Auto Encoders and RBMs for Spam Filtering, Machine Learning based DDoS Detection and Mitigation.

Basic deep learning concepts, Cybersecurity and Deep Learning- Intelligence through Data Integration, Cryptomodule Identification in Malwares, Deep learning for malware analysis and Intrusion detection, Transfer Learning for Cyber Security, LLMs for Cyber Security, Real world case studies on cyber threats.

Textbooks / References

- *Deep Learning Applications for Cyber Security (Advanced Sciences and Technologies for Security Applications) by Mamoun Alazab, MingJian Tang, 2020.*
- *Hands-On Machine Learning for Cybersecurity by Soma Halder, Sinan Ozdemir, 2018.*
- *Intrusion detection and Prevention by Carl Enrolf, Eugene Schultz, Jim Mellander, McGraw Hill, 2003.*
- *The art of software security assessment: Identifying and preventing software vulnerabilities by Dowd, Mark, John McDonald, and Justin Schuh, Pearson Education, 2006.*
- *Data Mining and Machine learning in Cybersecurity by Sumeet Dua and Xian Du CRC Press, 2011.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20

External	End Semester Exam/Term Project	1	30

24DS741	**Computer Vision**	**L-T-P-C: 2-0-3-3**

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
CO1	3	3	1	-	-	-	-	-	2
CO2	3	2	-	-	1	-	-	2	2
CO3	3	3	2	-	-	-	2	-	2
CO4	-	-	3	1	2	-	-	-	2
CO5	- -	-	-	3	3	-	-	2	2

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).

Textbooks / 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.*
- *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information, by David Marr, The MIT Press, ISBN-10: 0262514621, ISBN-13: 978-0262514620.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS742	Reinforcement Learning	L-T-P-C: 2-0-3-3

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 it'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
CO1	3	1	2	1	-	-	-	-	2
CO2	3	1	2	1	-	-	3	-	2
CO3	-	3	2	3	3	-	-	-	3
CO4	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. RLHF – Reinforcement Learning through Human Feedback.

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	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS743	Blockchain Technology	L-T-P-C: 2-0-3-3

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: To understand the concepts of cryptocurrency, blockchain, and distributed ledger technologies.

CO2: To analyze the application and impact of blockchain technology in various industries.

CO3: To evaluate security issues related to blockchain and cryptocurrency.

CO4: To design and analyze the impact of blockchain technology for real world applications.

CO-PO Mapping

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

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

- *Mastering Blockchain - Distributed ledgers, decentralization and smart contracts explained by Imran Bashir, Packt Publishing Ltd, Second Edition, 2018*
- *Mastering Bitcoin: Unlocking Digital Cryptocurrencies by Andreas Antonopoulos, O'Reilly Publishing 2014.*
- *Blockchain Basics: A Non-Technical Introduction in 25 Steps by Daniel Drescher, Apress, First Edition, 2017.*

- *Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction by Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, Princeton University Press, 2016.*
- *The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology by Vitalik Buterin, William Mougayar, Wiley; 1st edition, 2016.*
- *Bitcoin: A Peer-to Peer Electronic Cash System by Satoshi Nakamoto, Online 2009, https://bitcoin.org/bitcoin.pdf .*
- *Ethereum White Paper by Vitalik Buterin, Online 2017, https://ethereum.org/en/whitepaper/.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS744	**Predictive Analytics for Internet of Things**	**L-T-P-C: 2-0-3-3**

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 cloud data.
CO4: To apply predictive analytics to real world problems.

CO-PO Mapping

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

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, Visualization and Dashboard – Designing visual analysis for IoT data- creating dashboard –creating and visualizing alerts – Exploring and visualizing data, solution for industry specific analysis problem, understand streaming data analytics for IoT.

Textbooks / References

- *Big Data Analytics for Internet of Things by Tausifa Jan Saleem, Mohammed Ahsan Chishti, 1st Edition.*
- *Internet of Things: A Hands-on Approach by Vijay Madisetti and Arshdeep Bahga, Hardcover – Import, 2015.*
- *Internet of Things: Principles and Paradigms by Vahid Dastjerdi, Rajkumar Buyya, 2016.*
- *Analytics for Internet of Things by Andrew Minteer, Packt Publications Mumbai, 2017.*
- *Big Data Analytics for Cloud, IoT and Cognitive Computing by Min Chen, Kai Hwang, Hardcover, 2017.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20

Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS745	**Cloud Computing and Security in the Cloud**	**L-T-P-C: 2-0-3-3**

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:** Develop the concepts on 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:** Familiarize 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**
CO1	3	1	2	1	-	-	-	2	2
CO2	3	1	2	1	-	-	-	2	2
CO3	-	3	2	3	3	-	-	2	2
CO4	3	3	3	3	-	-	2	3	2
CO5	2	2	1	2	2		2	2	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	2	20
Internal	Assignments/Presentations/ Case Study	2	30

Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS747	**Materials Informatics**	**L-T-P-C: 2-0-3-3**

Course Objectives

- The course aims to introduce students to the effective management and organization of materials data using tools and techniques from the field of informatics.
- This course will also familiarize students with the application of machine and deep learning algorithms to predict materials properties, design new materials, and optimize material performance.
- The students will be provided with the hands-on experience of AI/ML driven materials design and discovery.

Course Outcomes:

CO1: Querying available materials databases for optimal design
CO2: Acquire knowledge in conventional machine learning algorithms and a framework for their integration with materials design and discovery
CO3: Accelerated materials design and discovery using Bayesian approach.
CO4: Apply natural language processing in materials science for data mining.

CO-PO Mapping

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

Syllabus

Introduction: Historical paradigm of materials discovery; understand property, structure and process spaces; role of data science in materials knowledge system

Materials Databases and Featurization: String and Graph representations. Familiarization to materials project API; querying the database; composition-based feature vector; structure-based feature vector; handling molecular descriptors; crystal graph networks.

Machine Learning: Simple linear/nonlinear models; test/train/validation/metrics; ensemble models; support vector machines; artificial neural networks

Accelerating materials design and discovery: A framework for optimal design of materials system; Bayesian Inference; Gaussian processes; Bayesian Optimization; Data-intensive investigations: uncertainty quantification, sensitivity analysis, multi-objective optimization

Natural Language Processing (NLP) for Materials: Design of materials embeddings; Mat2Vec; Chemical similarity-based embeddings; named entity recognition (NER) in Materials science.

Active Learning: Leveraging first principles density functional theory (DFT) computations

Textbooks / References

- *Olexandr Isayev, Alexander Tropsha, Stefano Curtarolo, Materials Informatics, Wiley.*
- *Murdock, R.J., Kauwe, S.K., Wang, A.Y.T. and Sparks, T.D., 2020. "Is domain knowledge necessary for machine learning materials properties?" Integrating Materials and Manufacturing Innovation, 9, pp.221-227.*
- *Sayeed, H.M., Baird, S.G. and Sparks, T.D., 2023. Structure feature vectors derived from Robocrystallographer text descriptions of crystal structures using word embeddings.*
- *Anoop Krishnan N. M., Kodamana H., Bhattoo R., "Machine Learning for Materials Discovery," 1st Edition, Springer, 2024.*
- *Roman Garnett, "Bayesian Optimization", Cambridge University Press*
- *Hargreaves, C.J., Dyer, M.S., Gaultois, M.W., Kurlin, V.A. and Rosseinsky, M.J., 2020. The earth mover's distance as a metric for the space of inorganic compositions. Chemistry of Materials, 32(24), pp.10610-10620.*
- *Tshitoyan, V., Dagdelen, J., Weston, L., Dunn, A., Rong, Z., Kononova, O., Persson, K.A., Ceder, G. and Jain, A., 2019. Unsupervised word embeddings capture latent knowledge from materials science literature. Nature, 571(7763), pp.95-98.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20

Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS746	**Financial Data Analytics**	**L-T-P-C: 2-0-3-3**

Course Objectives

- The course aim to develop a deep understanding and vitualization of various types of financial data, including market data, and economic indicators etc.
- The course provides advanced analytical skills for processing and analysing financial data. It covers a range of techniques, including data wrangling, exploratory data analysis (EDA), time series analysis, and predictive modelling.
- The course introduced students to concepts and methodologies for risk management, portfolio optimization.
- Hands-on experience with industry-standard financial analytics tools and platforms will be provide in the course.

Course Outcomes:

CO1: Acquire knowledge of the basic characteristics of financial time series data
CO2: Ability to analyze and model financial data.
CO3: Evaluate and model risk across various financial assets.
CO4: Utilize advanced R or Python routines for analytical finance.

CO-PO Mapping

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

Syllabus

Introduction to financial time series and their characteristics -- Exploratory data analysis -- Linear time series analysis(AR, MA, ARIMA, unit-root non-stationarity, seasonality model) -- Conditional heteroscedastic models/ Modeling volatility (ARCH, GARCH) -- Non-linear model and their application(TAR, STAR) -- High-frequency data analysis and market microstructure(nonsynchronous trading, bid-ask spread, model for price change, duration model) -- Derivative pricing / Continuous time models (black sholes model) -- Asset portfolio models(basics of portfolio construction, Markowitz theorem, capital asset pricing model, diversification and portfolio optimization) -- Measuring and modelling risk(extreme value, quantile estimation and Value at Risk (VaR)) -- Modeling credit risk (corporate liabilities as contingent claims, endogenous default boundaries and optional capital structure, intensity modeling, rating based term-structure models, credit risk and interest-rate Swaps, modelling dependent defaults) -- Derivative pricing / Continuous time models (black sholes model) -- Multivariate time series analysis(vector autoregressive model).

Textbooks / References

- *Analysis of Financial Time Series (Wiley Series in Probability and Statistics) Ruey Tsay*
- *Time series analysis and its applications. Shumway and Stoffer.*
- *Advances in financial machine learning. Marcos Lopez de Prado*
- *Hilpisch, Yves. Python for Finance: Analyze big financial data. " O'Reilly Media, Inc.", 2014.*
- *Ruey S. Tsay (2012), "An Introduction to Analysis of Financial Data with R" , Wiley, ISBN: 978-0-470-89081-3*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS748	**Integration of data science and system biology**	**L-T-P-C: 2-0-3-3**

Course Objective:

- The course will lay down the application of data science into system biology which is an emerging research field in bioscience.
- The course will explore the concept of Markov modelling of stochastic processes, mathematical formulation of the stochastic dynamics along with the simulation techniques of the stochastic processes.
- The course will provide the theoretical techniques to handle the big data obtained from the stochastic single molecular experiments and imaging processes.

Course Outcome:

- **CO1:** Enable to handle the random big data obtained from the stochastic processes; Able to get an idea about the application of the data sciences into study of the system biology.
- **CO2:** Obtain an idea about the Markovian description for the stochastic processes; Able to formulate the stochastic equation of motion *i.e.,* the Langevin equation in continuous space as well as master equation in discrete space to study the stochastic dynamics.
- **CO3:** Learn about the simulation techniques of stochastic processes and network dynamics *i.e.,* the kinetic Monte Carlo and the Langevin dynamics simulation techniques.
- **CO4:** Able to describe the stochastic dynamics by applying the concept of the non-equilibrium statistical mechanics which is widely used in Physics, Chemistry, Biology as well as economics.

CO-PO Mapping

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

Syllabus

System biology: its necessity and application; Concept of network in system biology; Inter and intra-cellular networks; Stochastic time-evaluation of the cellular network; Explanation for obtaining big data from cellular network dynamics and its importance by considering gene-expression network as model; Mathematical modelling of the dynamics of cellular network; Concept of continuous and discrete state spaces; Understanding of the Markov processes and transition probabilities.

General design principles of biological networks - autoregulation, feedforward, and feedback loops. Network motifs in transcription, signal transduction and neuronal networks.

Stochastic dynamics at continuous space; Winner and Ornstein-Uhlenbeck processes; Understanding of the drift and diffusion terms; Construction of the Langevin equation; Introduction to stochastic integrals: Ito and Stratonovich descriptions; Kolmogorov forward and backward differential equations; Introduction of the Langevin dynamics simulation; Stochastic dynamics in discrete space; Formulation of the master equation; Introduction to the Kinetic Monte-Carlo Simulation.

Formulation of the cell phenotypic transitions following the dynamical systems theory; Procedure for the extraction of dynamical information from snapshot data and from live-cell time series data; Challenges and perspectives.

Textbooks / References

- *An Introduction to Systems Biology: Design Principles of Biological Circuits, Uri Alon, (Chapman & Hall/CRC Mathematical and Computational Biology), 2007.*
- *Data Mining for System Biology, Methods, and Protocols, Hiroshi Mamitsuka, Chapman & Hall/CRC Mathematical and Computational Biology, 2018.*
- *Big Data Mining, Network Modelling, and Genome-Wide Data Identification, Bor-Sen Chen, Cheng-Wei Li, Elsevier, 2016.*
- *Stochastic processes in physics and Chemistry, N. G. Van Kampen, 3rd edition, Science Direct, 2007.*
- *Handbook of stochastic methods for physics, chemistry and natural sciences, C. W. Gardiner, 2nd edition, 1985.*
- *The Fokker-Planck equation methods of solution and application, H. Risken, 2nd edition, Springer, 1996.*
- *Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC Press, London, 2007.*

Evaluation pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

24DS749	Introduction to Graph Theory	L-T-P-C: 2-0-3-3

Course Objectives

- Achieve proficiency in fundamental graph theory concepts and definitions, and differentiate various graph types
- Explore key graph theory theorems, algorithms, and their applications.
- Gain exposure to advanced topics and recent developments in graph theory, including random graphs, spectral graph theory, and applications in computer science and biology.

Course Outcomes:

CO1: Ability to explain the basic concepts of graph theory.
CO2: Understand the importance of graph theory and represent real-world problems using graph theory.
CO3: Learn to apply different algorithms of graph theory to solve network-related problems across diverse fields.
CO4: Develop an understanding of graph mining, graph machine learning, and graph neural networks.

CO-PO Mapping

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

Syllabus

Fundamental Graph Concepts: Definition and examples of different graph types and subgraphs, adjacent matrices, isomorphism, decompositions, Ramsey number, paths, cycles, trails, vertex degrees, and counting. a directed graph, weak connectivity, connectivity, strong components, etc.
Trees: Cut edges and bonds, cut vertices, Cayley's formula, spanning trees, Kruskal's theorem, and Dijkstra's theorem.

Connectivity: walks, trails, and paths, connectedness and components, blocks, 2-connected and 3-connected graphs, Eulerian graphs, Euler tours, Hamilton cycles, Menger's theorem.
Matching and Covering: bipartite matching, vertex cover, edge cover, independent set, M-alternating path, Hall's theorem.
Colorings: vertex coloring, Brooks' theorem, edge coloring, Vizing's theorem, girth and chromatic numbers, list coloring, chromatic index, chromatic polynomials, k-critical graphs.
Planarity: plane and planar graphs, 5-coloring planar graphs, Kuratowski's theorem.
Special Classes of Graphs: Perfect graph, interval graph, chordal graph, boxicity, sphericity, 4-color conjecture.
Graph Centrality measures, Spectral Graph Theory - Analysis of Eigenvalues/Eigenvectors of Adjacency and Laplacian Matrices.
Network Flow: Max flow and mincut theorem, circulations, tensions, Ford-Fulkerson labeling algorithm, flow integrality
GraphAI: Introduction to graph mining, graph neural networks, and graph machine learning.

Textbooks / References

- *Reinhard Diestel, "Graph Theory", Springer (2010)*
- *Douglas B. West, "Introduction to Graph Theory", Prentice Hall (2001)*
- *A. Bondy and U. S. R. Murty, "Graph Theory", Springer (2008)*
- *B. Bollabas, "Modern Graph Theory", Springer (1998)*
- *M. E. J. Newman, Networks: An Introduction, Oxford University Press, Oxford, 2010.*

Evaluation Pattern

Assessment component	Type of Assessment	Minimum Number of Assessments	Weightage (%)
Internal	Quizzes	2	20
Internal	Assignments/Presentations/ Case Study	2	30
Internal	Mid-Term Exam	1	20
External	End Semester Exam/Term Project	1	30

22AVP103 Mastery Over Mind (MAOM) 1-0-2 2

1. Course Overview

Master Over the Mind (MAOM) is an Amrita initiative to implement schemes and organise university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3). This program as part of our efforts for sustainable stress reduction gives an introduction to immediate and long-term benefits and equips every attendee to manage stressful emotions and anxiety facilitating inner peace and harmony.

With a meditation technique offered by Amrita Chancellor and world-renowned humanitarian and spiritual leader, Sri Mata Amritanandamayi Devi (Amma), this course has been planned to be offered to all students of all campuses of AMRITA, starting off with all first years, wherein one hour per week is completely dedicated for guided practical meditation session and one hour on the theory aspects of MAOM. The theory section comprises lecture hours within a structured syllabus and will include invited guest lecture series from eminent personalities from diverse fields of excellence. This course will enhance the understanding of experiential learning based on university's mission: "Education for Life along with Education for Living", and is aimed to allow learners to realize and rediscover the infinite potential of one's true Being and the fulfilment of life's goals.

2. Course Syllabus

Unit 1 (4 hours)

Causes of Stress: The problem of not being relaxed. Need for meditation -basics of stress management at home and workplace. Traditions and Culture. Principles of

meditation– promote a sense of control and autonomy in the Universal Human Value System. Different stages of Meditation. Various Meditation Models. Various practices of Meditation techniques in different schools of philosophy and Indian Knowledge System.

Unit 2 (4 hours)

Improving work and study performance. Meditation in daily life. Cultivating compassion and good mental health with an attitude of openness and acceptance. Research and Science of Meditation: Significance of practising meditation and perspectives from diverse fields like science, medicine, technology. philosophy, culture, arts, management, sports, economics, healthcare, environment etc. The role of meditation for stress and anxiety reduction in one's life with insights based on recent cutting-edge technology. The effect of practicing meditation for the wholesome wellbeing of an individual.

Unit 3 (4 hours)

Communications: principles of conscious communication. Relationships and empathy: meditative approach in managing and maintaining better relationships in life during the interactions in the world, role of MAOM in developing compassion, empathy and responsibility, instilling interest, and orientation to humanitarian projects as a key to harness intelligence and compassion in youth. Methodologies to evaluate effective awareness and relaxation gained from meditation. Evaluating the global transformation

through meditation by instilling human values which leads to service learning and compassion driven research.

TEXT BOOKS:

1.Mata Amritanandamayi Devi, “Cultivating Strength and vitality,” published by Mata

Amritanandamayi Math, Dec 2019

2.Swami Amritaswarupananda Puri ,”The Color of Rainbow “ published by MAM, Amritapuri.

REFERENCES:

1.Craig Groeschel, “Winning the War in Your Mind: Change Your Thinking, Change Your Life” Zondervan Publishers, February 2019

2.R Nagarathna et al, “New Perspectives in Stress Management “Swami Vivekananda Yoga Prakashana publications, Jan 1986

3. Swami Amritaswarupananda Puri “Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation”, August 2019

4. Swami Amritaswarupananda Puri “From Amma’s Heart - Amma’s answer to questions raised during world tours” March 2018

5. Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.

6. Mata Amritanandamayi Devi “Compassion :The only way to Peace:Paris Speech”, MA Center, April 2016.

7. Mata Amritanandamayi Devi “Understanding and collaboration between Religions”, MA Center, April 2016.

8. Mata Amritanandamayi Devi “Awakening of Universal Motherhood: Geneva Speech” M A center, April 2016.

3. Evaluation and Grading

<table>
<tr><td colspan="3">Internal</td><td>External</td><td>Total</td></tr>
<tr><td>Components</td><td colspan="2">Weightage</td><td rowspan="2">Practical (attendance and class participation) 60%</td><td rowspan="2">100%</td></tr>
<tr><td>Quizzes(based on the reading material)</td><td>20%</td><td>40%</td></tr>
</table>

Assignments (Based on webinars and lecture series)	20%			

4. Course Outcomes (CO)

CO1: Relate to the causes of stress in one's life.

CO2: Experiment with a range of relaxation techniques

CO3: Model a meditative approach to work, study, and life.

CO4: Develop appropriate practice of MA-OM technique that is effective in one's life

CO5: Inculcate a higher level of awareness and focus.

CO6: Evaluate the impact of a meditation technique

***Program Outcomes (PO) (As given by NBA and ABET)**

PO1: Engineering Knowledge

PO2: Problem Analysis

PO3: Design/Development of Solutions

PO4: Conduct Investigations of complex problems

PO5: Modern tools usage

PO6: Engineer and Society

PO7: Environment and Sustainability

PO8: Ethics

PO9: Individual & Team work

PO10: Communication

PO11: Project management & Finance

PO12: Lifelong learning

CO – PO Affinity Map

P O/ C O	P O 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3

23HU601	**Career Competency I**							**L-T-P-C: 0-0-3-P/F**							
CO 1	3	3	3	2		-	2	3	-	3	-	3	-	-	-
CO 2	3	3	3	2	2	_	2	3	3	3	-	3	-	-	-
CO 3	3	3	2	2	2	2	2	3	3	3	-	3	-	-	-
CO 4	3	3	3	2	-	2	3	3	3	3	-	3	-	-	-
CO 5	3	2	2	2	-	2	-	3	2	2	-	2	-	-	-
CO 6	3	2	2	2	3	2	_	3	2	2	-	2	-	-	-

Prerequisite:

An open mind and the urge for self-development, basic English language skills and knowledge of high school level arithmetic.

Course Objectives:

- Help students transit from campus to corporate and enhance their soft skills
- Enable students to understand the importance of goal setting and time management skills
- Support them in developing their problem solving and reasoning skills
- Inspire students to enhance their diction, grammar and verbal reasoning skills

Course Outcomes:

CO1: Soft Skills - To develop positive mindset, communicate professionally, manage time effectively and set personal goals and achieve them.

CO2: Soft Skills - To make formal and informal presentations with self-confidence.

CO3: Aptitude - To analyze, understand and employ the most suitable methods to solve questions on arithmetic and algebra.

CO4: Aptitude - To analyze, understand and apply suitable techniques to solve questions on logical reasoning and data analysis.

CO5: Verbal - To infer the meaning of words and use them in the right context. To have a better understanding of the nuances of English grammar and become capable of applying them effectively.

CO6: Verbal - To identify the relationship between words using reasoning skills. To understand and analyze arguments and use inductive/deductive reasoning to arrive at conclusions and communicate ideas/perspectives convincingly.

CO-PO Mapping

PO/CO	PO1	PO2	PO3
CO1	2	1	-
CO2	2	1	-
CO3	2	1	-
CO4	2	1	-
CO5	1	2	-
CO6	2	2	-

Syllabus:

Soft Skills

Introduction to 'campus to corporate transition':

Communication and listening skills: communication process, barriers to communication, verbal and non-verbal communications, elements of effective communication, listening skills, empathetic listening, role of perception in communication.

Assertiveness skills: the concept, assertiveness and self-esteem, advantages of being assertive, assertiveness and organizational effectiveness.

Self-perception and self-confidence: locus of control (internal v/s external), person perception, social perception, attribution theories-self presentation and impression management, the concept of self and self-confidence, how to develop self-confidence.

Goal setting: the concept, personal values and personal goals, goal setting theory, six areas of goal setting, process of goal setting: SMART goals, how to set personal goals

Time management: the value of time, setting goals/ planning and prioritizing, check the time killing habits, procrastination, tools for time management, rules for time management, strategies for effective time management

Presentation skills: the process of presentation, adult learning principles, preparation and planning, practice, delivery, effective use of voice and body language, effective use of audio visual aids, dos and don'ts of effective presentation

Public speaking-an art, language fluency, the domain expertise (Business GK, Current affairs), self-confidence, the audience, learning principles, body language, energy level and conviction, student presentations in teams of five with debriefing

Verbal

Vocabulary: Familiarize students with the etymology of words, help them realize the relevance of word analysis and enable them to answer synonym and antonym questions. Create an awareness about the frequently misspelt words, commonly confused words and wrong form of words in English.

Grammar: Train students to understand the nuances of English Grammar and thereby enable them to spot grammatical errors and punctuation errors in sentences.

Reasoning: Stress the importance of understanding the relationship between words through analogy questions and learn logical reasoning through syllogism questions. Emphasize the importance of avoiding the gap (assumption) in arguments/ statements/ communication.

Oral Communication Skills: Aid students in using the gift of the gab to improve their debating skills.

Writing Skills: Introduce formal written communication and keep the students informed about the etiquettes of email writing. Make students practise writing emails especially composing job application emails.

Aptitude

Numbers: Types, Power Cycles, Divisibility, Prime, Factors & Multiples, HCF & LCM, Surds, Indices, Square roots, Cube Roots and Simplification.

Percentage: Basics, Profit, Loss & Discount, and Simple & Compound Interest.

Ratio, Proportion & Variation: Basics, Alligations, Mixtures, and Partnership.

Averages: Basics, and Weighted Average.

Time and Work: Basics, Pipes & Cistern, and Work Equivalence.

Time, Speed and Distance: Basics, Average Speed, Relative Speed, Boats & Streams, Races and Circular tracks.

Statistics: Mean, Median, Mode, Range, Variance, Quartile Deviation and Standard Deviation.

Data Interpretation: Tables, Bar Diagrams, Line Graphs, Pie Charts, Caselets, Mixed Varieties, and other forms of data representation.

Equations: Basics, Linear, Quadratic, Equations of Higher Degree and Problems on ages.

Logarithms, Inequalities and Modulus: Basics

References

Soft Skills:

Communication and listening skills:

- Andrew J DuRbin , "Applied Psychology: Individual and organizational effectiveness", Pearson-Merril Prentice Hall, 2004
- Michael G Aamodt, "An Applied Approach, 6th edition", Wadsworth Cengage Learning, 2010

Assertiveness skills:

- Robert Bolton, Dorothy Grover Bolton, "People Style at Work..and Beyond: Making Bad Relationships Good and Good", Ridge Associates Inc., 2009
- John Hayes "Interpersonal skills at work", Routledge, 2003
- Nord, W. R., Brief, A. P., Atieh, J. M., & Doherty, E. M., "Meanings of occupational work: A collection of essays (pp. 21- 64)", Lexington, MA: Lexington Books, 1990

Self-perception and self-confidence:

- Mark J Martinko, "Attribution theory: an organizational perspective", St. Lucie, 1995
- Miles Hewstone, "Attribution Theory: Social and Functional Extensions", Blackwell, 1983

Time management:

- Stephen Covey, "The habits of highly effective people", Free press Revised edition, 2004
- Kenneth H Blanchard , "The 25 Best Time Management Tools & Techniques: How to Get More Done Without Driving Yourself Crazy" , Peak Performance Press, 1st edition 2005
- Kenneth H. Blanchard and Spencer Johnson, "The One Minute Manager" , William Morrow, 1984

Verbal:

- Erica Meltzer, "The Ultimate Guide to SAT Grammar"
- Green, Sharon, and Ira K. Wolf, "Barron's New GRE", Barron's Educational Series, 2011
- Jeff Kolby, Scott Thornburg & Kathleen Pierce, "Nova's GRE Prep Course"
- Kaplan, "Kaplan New GRE Premier", 2011-2012
- Kaplan's GRE Comprehensive Programme
- Lewis Norman, "Word Power Made Easy", Goyal Publishers, Reprint edition, 1 June 2011
- Manhattan Prep, "GRE Verbal Strategies Effective Strategies Practice from 99th Percentile Instructors"
- Pearson- "A Complete Manual for CAT", 2013
- R.S. Aggarwal, "A Modern Approach to Verbal Reasoning"
- S. Upendran, "Know Your English", Universities Press (India) Limited, 2015
- Sharon Weiner Green, Ira K. Wolf, "Barron's New GRE, 19th edition (Barron's GRE)", 2019
- Wren & Martin, "English Grammar & Composition"
- www.bbc.co.uk/learningenglish
- www.cambridgeenglish.org
- www.englishforeveryone.org
- www.merriam-webster.com

Aptitude:

- Arun Sharma, "How to Prepare for Quantitative Aptitude for the CAT Common Admission Test", Tata Mc Graw Hills, 5th Edition , 2012

- Arun Sharma, “How to Prepare for Logical Reasoning for the CAT Common Admission Test”, Tata Mc Graw Hills, 2nd Edition, 2014
- Arun Sharma, “How to Prepare for Data Interpretation for the CAT Common Admission Test”, Tata Mc Graw Hills, 3nd Edition, 2015
- R.S. Aggarwal, “Quantitative Aptitude For Competitive Examinations”, S. Chand Publishing, 2015
- R.S. Aggarwal, “A Modern Approach To Verbal & Non-Verbal Reasoning”, S. Chand Publishing, Revised -2015
- Sarvesh Verma, “Quantitative Aptitude-Quantum CAT”, Arihant Publications, 2016
- www.mbatious.com
- www.campusgate.co.in
- www.careerbless.com

Evaluation Pattern

Assessment	**Internal**	**External**
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50
Pass / Fail		

*CA - Can be **presentations, speaking activities and tests.**

23HU611	**Career Competency II**	**L-T-P-C: 0-0-3-1**

Pre-requisite: Willingness to learn, team spirit, basic English language and communication skills and knowledge of high school level arithmetic.

Course Objectives:

- Help students to understand the importance of interpersonal skills and team work
- Prepare the students for effective group discussions and interviews participation.
- Help students to sharpen their problem solving and reasoning skills
- Empower students to communicate effectively by using the correct diction, grammar and verbal reasoning skills

Course Outcomes:

CO1: Soft Skills - To demonstrate good interpersonal skills, solve problems and effectively participate in group discussions.

CO2: Soft Skills - To write technical resume and perform effectively in interviews.

CO3: Aptitude - To identify, investigate and arrive at appropriate strategies to solve questions on arithmetic by managing time effectively.

CO4: Aptitude - To investigate, understand and use appropriate techniques to solve questions on logical reasoning and data analysis by managing time effectively.

C05: Verbal - To be able to use diction that is more refined and appropriate and to be competent in knowledge of grammar to correct/improve sentences

C06: Verbal - To be able to examine, interpret and investigate passages and to be able to generate ideas, structure them logically and express them in a style that is comprehensible to the audience/recipient.

CO-PO Mapping

PO/CO	PO1	PO2	PO3
CO1	2	1	-
CO2	2	1	-
CO3	2	1	-
CO4	2	1	-
CO5	1	2	-
CO6	2	2	-

Syllabus

Soft Skills

Interpersonal skill: ability to manage conflict, flexibility, empathetic listening, assertiveness, stress management, problem solving, understanding one's own interpersonal needs, role of effective team work in organizations

Group problem solving: the process, the challenges, the skills and knowledge required for the same.

Conflict management: the concept, its impact and importance in personal and professional lives, (activity to identify personal style of conflict management, developing insights that helps in future conflict management situations.)

Team building and working effectively in teams: the concept of groups (teams), different stages of group formation, process of team building, group dynamics, characteristics of effective team, role of leadership in team effectiveness. (Exercise to demonstrate the process of emergence of leadership in a group, debrief and reflection), group discussions.

Interview skills: what is the purpose of a job interview, types of job interviews, how to prepare for an interview, dos and don'ts of interview, One on one mock interview sessions with each student

Verbal

Vocabulary: Help students understand the usage of words in different contexts. Stress the importance of using refined language through idioms and phrasal verbs.

Grammar: Enable students to identify poorly constructed sentences or incorrect sentences and improvise or correct them.

Reasoning: Facilitate the student to tap her/his reasoning skills through critical reasoning questions and logical ordering of sentences.

Reading Comprehension: Enlighten students on the different strategies involved in tackling reading comprehension questions.

Public Speaking Skills: Empower students to overcome glossophobia and speak effectively and confidently before an audience.

Writing Skills: Practice closet tests that assess basic knowledge and skills in usage and mechanics of writing such as punctuation, basic grammar and usage, sentence structure and rhetorical skills such as writing strategy, organization, and style.

Aptitude

Sequence and Series: Basics, AP, GP, HP, and Special Series.

Geometry: 2D, 3D, Coordinate Geometry, and Heights & Distance.

Permutations & Combinations: Basics, Fundamental Counting Principle, Circular Arrangements, and Derangements.

Probability: Basics, Addition & Multiplication Theorems, Conditional Probability and Bayes' Theorem.

Logical Reasoning I: Arrangements, Sequencing, Scheduling, Venn Diagram, Network Diagrams, Binary Logic, and Logical Connectives, Clocks, Calendars, Cubes, Non-Verbal reasoning and Symbol based reasoning.

Logical Reasoning II: Blood Relations, Direction Test, Syllogisms, Series, Odd man out, Coding & Decoding, Cryptarithmetic Problems and Input - Output Reasoning.

Data Sufficiency: Introduction, 5 Options Data Sufficiency and 4 Options Data Sufficiency.

Campus recruitment papers: Discussion of previous year question papers of all major recruiters of Amrita Vishwa Vidyapeetham.

Miscellaneous: Interview Puzzles, Calculation Techniques and Time Management Strategies.

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Evaluation Pattern

Assessment	**Internal**	**External**
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**