ऑनलाइन शिक्षा और कौशल
Online Education and Skilling
Indian Institute of Technology Guwahati

BSc (Hons) Data Science and AI Course Syllabus

DA101 - Basic English

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:

Listening: What is listening, difference between listening and speaking, barriers to listening, effective listening strategies, comprehending social conversation, comprehending narrations and academic lectures

Speaking: Understanding accent (intelligibility, Indian and non-Indian accents), nuances of fluency; understanding effective speaking strategies, using language in various situations such as - introducing oneself and others in formal and informal situations, asking for and giving information, describing people, places and objects, narrating events, explaining processes and products, expressing opinions, arguing, giving instructions, participating in conversations and group discussions, understanding turn-taking strategies, making short presentations

Reading: Reading simple narratives and comprehending the gist, identifying topic sentences, identifying cohesive devices and their functions, comprehending texts of different genres

Vocabulary: understanding different aspects of a word, learning strategies to develop vocabulary, using dictionaries

Grammar: articles, quantifiers, punctuation, tenses, gerunds, infinitives, participles, subject-verb agreement, adverbs, nouns, pronouns, prepositions, connectives, adjectives, common errors

Writing: writing paragraphs, narratives, summarizing, paraphrasing, note-taking, note-making, reviews, and short reports

Textbooks:

- V. Sasikumar et al., A Course in Listening and Speaking I, 2nd Edition, Cambridge University Press, 2006.
- Raymond Murphy, English Grammar in Use, 5th Edition, Cambridge University Press, 2019.

- Alice Oshima and Ann Hogue, Introduction to Academic Writing, 3rd Edition, Pearson Longman, 2007.

References:

- Oxford Advanced Learner's Dictionary of English, 9th Edition, 2016.
- John and Liz Soars, New Headway, 3rd Edition, Oxford University Press, 2007.

DA102 - Data Analysis Basics

Credits: 2-0-4-8 | **Pre-requisite:** None

Syllabus:
Different forms of data (structured, unstructured, temporal and spatial) and their representation. Data files and their formats: csv, xlsx, text files, coded files, etc. Cleansing of data (missing values, duplicates, null values, data not in proper format, misplaced delimiter, embedded space characters or nonprinting characters, removal of unnecessary spaces), Data wrangling. Statistical analysis of data: tabulation, measure of central tendency (mean, median, mode), measure of dispersion and variance (range, variation, standard deviation), measure of skewness, time-series analysis using tools such as Excel and Spreadsheet. Data visualization for decision making: organizing and summarizing data using charts and graphs, PivotTables and Pivot Charts. Curve fitting and regression.

Textbooks:

- Wayne Winston, Microsoft Excel Data Analysis and Business Modeling, 7th Edition, Pearson Education, Inc., 2022.
- Michael Alexander, Richard Kusleika, John Walkenbach, Excel 2019 Bible, 1st Edition, Wiley, 2018.

References:

- Gordon S. Linoff, Data Analysis Using SQL and Excel, 2nd Edition, Wiley Publishing Inc., 2016.

DA103 - Introduction to Statistics

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Basics of probability and random variables, distribution functions, probability mass and density functions, functions of random variables, standard univariate discrete and continuous distributions; Mathematical expectations, moments, moment generating functions, inequalities; Two dimensional random variables, joint, marginal and conditional distributions, conditional expectation, independence, covariance, correlation; Law of large numbers, Central limit theorem.

Textbooks:

- Hogg, R.V., McKean, J. and Craig, A.T., Introduction to Mathematical Statistics, 7th Edition, Pearson Education, 2012.
- Rice, J.A., Mathematical Statistics and Data Analysis, 3rd Edition, Cengage Learning, 2006.

References:

- Rohatgi, V.K. and Saleh, A.M.E., An Introduction to Probability and Statistics, 3rd Edition, John Wiley & Sons, 2015.

DA104 - C Programming

Credits: 2-0-4-8 | **Pre-requisite:** None

Syllabus:
Basic structure of a C program, executing a C program; data types, operators and expressions: C tokens, keywords and identifiers, variables and constants, data types and sizes, declaration of variables and assigning values, symbolic constants, arithmetic, relational and logical Operators, type conversions, increment and decrement operators, bitwise operators, assignment operators and expressions, conditional expressions, precedence and order of evaluation; Branching and looping: if statement, if-else statement, nesting of if-else statements, switch statement, loops – while, for and do-while, break and continue, goto and labels; Functions and Program Structure: basics of C functions, return values and their types, external variables, header files, recursion, the C preprocessor, pointers and arrays, address arithmetic, command-line arguments, pointers to functions, basics of structures, pointers to structures; Input and Output: standard input and output, formatted input and output (scanf and printf), file access, error handling.

Textbooks:

- Kernighan B.W and Dennis M. Ritchie, The C Programming Language, 2nd Edition, Pearson Education India, 2015.
- Byron S. Gottfried, Programming with C, 4th Edition, McGraw Hill (Schaum's Outlines), 2018.

References: To be updated.

DA105 - Linear Algebra

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Systems of linear equations, matrices, Solving systems of linear equations: Gaussian elimination, echelon form, column space, null space, rank of a matrix, inverse, determinant and their properties, Cramer's rule; Vector spaces (over the field of real and complex

numbers), subspaces, spanning set, linear independence, basis and dimension; Linear transformations, rank-nullity theorem, matrix of a linear transformation, change of basis and similarity; Eigenvalues and eigenvectors, algebraic and geometric multiplicity, similarity and diagonalization; Inner-product spaces, Gram-Schmidt process, orthonormal basis; Orthogonal, Hermitian and symmetric matrices, positive definite matrices, QR factorization, singular value decomposition. Introduction to Matrix Calculus.

Textbooks:

- David Poole, Linear Algebra: A Modern Introduction, 4th Edition, Cengage Learning, 2014.
- Seymour Lipschutz and Marc Lars Lipson, Linear Algebra, 4th Edition, McGraw Hill (Schaum's Outline Series), 2009.

References: To be updated.

DA106 - Data Science: An Introduction

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Overview of Data Science, Data Science task workflow; Data collection and management: Nature of data sets; Multimodal data, structured and unstructured data; Data collection and curation; Concepts in data management: XML and JSON file formats, basics of SQL; Data cleaning, exploration, plots: Reading and exporting data, cleaning data; Exploratory data analysis: Missing values, Outlier detection, Data Transformation. Model building, training, evaluation: Machine Learning Task Workflow, train/validation/test set preparation, Linear regression and Bayes Classifier; Model training and performance analysis; Examples of Data Science applications.

Textbooks:

- Rafael A. Irizarry, Introduction to Data Science: Data Analysis and Prediction Algorithms with R, 1st Edition, CRC Press, 2019.
- Hui Lin and Ming Li, Practitioner's Guide to Data Science, 1st Edition, Chapman & Hall/CRC, 2023.

References: To be updated.

DA107 - Computer System Tools

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Basic computer system architecture: Input, Output, Storage, Arithmetic Logic Unit, Control Unit; basics of CPU and GPU; Operating systems: different types and major functions; boot process; file system and partitions; OS installation; File system; Editors; Shell and shell

programming; Device drivers; Tools for computer system management under Windows and Unix/Linux environment: Resource Monitoring, Task/process management, System configuration, Storage management, Security and Network settings. Managing user accounts; Software package management.

Textbooks:

- Joan Lambert and Steve Lambert, Windows 10 Step by Step, Microsoft Press, 2015.
- Mark Sobell and Matthew Helmke, A Practical Guide to Linux Commands, Editors, and Shell Programming, 4th Edition, Addison-Wesley, 2017.

References:

- Randal E. Bryant and David R. O'Hallaron, Computer Systems: A Programmer's Perspective, 3rd Edition, Pearson Education Limited, 2016.

DA108 - Python Programming

Credits: 2-0-4-8 | **Pre-requisite:** None

Syllabus:
Fundamental concepts: Variables and identifiers, data types, literals, operators, expressions; Conditional statements; Loops; Data structures: Lists, dictionaries and sets; Functions: Procedural and Recursive; Classes; Exception handling; File handling.

Textbooks:

- Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem-Solving Focus, 1st Edition, Wiley, 2015.
- Mark Lutz, Learning Python, 5th Edition, O'Reilly Media, Inc., 2013.

References:

- Wes McKinney, Python for Data Analysis, O'Reilly Media, Inc., 2012.

DA109 - AI Basics

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Introduction to AI and Intelligent Agents; Problem solving by Searching: Uninformed and informed strategies; Logical Agents: Propositional and first order logic, inference; Knowledge representation and Automated Planning; Uncertain Knowledge and Reasoning: Quantifying uncertainty, probabilistic reasoning; Introduction to Learning: Supervised Learning, Unsupervised Learning, Reinforcement Learning; Applications and Case Studies.

Textbooks:

- S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, Pearson, 2020.
- R.S. Sutton and A.G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, MIT Press, 2018.

References: To be updated

DA110 - Data Structures

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Abstract data types, arrays, stacks, queues, linked lists, binary trees, tree traversals, heaps; Sorting – merge-sort, quicksort, heapsort; Searching - linear search, binary search, binary search trees, AVL trees, red-black trees, B-trees; Graph data structure and representations, breadth first search, depth first search; Hashing.

Textbooks:

- Michael T. Goodrich, Roberto Tamassia, and Michael H. Goldwasser, Data Structures and Algorithms in Python, John Wiley & Sons, 2013.
- Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 4th Edition, Pearson Education, Inc., 2014.

References: To be updated

DA111 - Algorithm Design & Analysis

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Asymptotic notation, space and time complexity; Sorting and order statistics - linear time sorting, quicksort; Searching; Design and analysis techniques - greedy method, divide-and-conquer, dynamic programming, amortized analysis; Graph algorithms - properties of BFS and DFS, connected components, topological sort, minimum spanning trees, shortest paths, max flow.

Textbooks:

- T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, Introduction to Algorithms, Prentice-Hall of India, 2009.
- A. V. Aho, J. E. Hopcroft, and J. D. Ullman, The Design and Analysis of Computer Algorithms, Pearson Education, 2006.

References: To be updated

DA112 - Introduction to R

Credits: 2-0-4-8 | **Pre-requisite:** None

Syllabus:
Introduction to R: Why R?, Installation of R, RStudio, Cloud Computing, RNW files; Basic Operations in R, R as a calculator; Working with data types and variables; Vector and Matrix operations in R; Relational and Logical Operators; Missing Data Handling; Conditional Statements – if and if-else, nested if, else if, and ifelse, switch and which commands; Loops – for loop, while loop, repeat loop; Functions in R; Sequences, Sorting, Ordering and Mode; Lists and Operations on Lists; Vector Indexing; Factors – Class and Unclass; Strings – Display and Formatting: print and format function, concatenate; Data Frames: Creation and Operations, Combining and Merging; Data Handling: Importing and Reading CSV, Excel data files; Saving and Writing Data Files; Organizing and commenting R code; Data Plotting and Visualization: Scatter plots, bar plots, subdivided bar plots, pie diagrams, histograms; Bivariate and three-dimensional scatter plots; Introduction to basic statistical functions and packages.

Textbooks:

- Pierre Lafaye de Micheaux, Rémy Drouilhet, Benoit Liquet, The R Software: Fundamentals of Programming and Statistical Analysis, Springer, 2013.
- Alain F. Zuur, Elena N. Ieno, Erik H.W.G. Meesters, A Beginner's Guide to R (Use R), Springer, 2009.
- Christian Heumann, Michael Schomaker, Shalabh, Introduction to Statistics and Data Analysis with Exercises, Solutions and Applications in R, Springer, 2016.

References:

Trimester-II Courses

DA201 - Relational Database Management Systems

Credits: 3-0-3-9 | **Pre-requisite:** None

Syllabus:
Relational DBMS: Entity relationship (ER) Model, relational algebras; SQL queries, constraints, triggers; SQL and front-end tools; Storage and file structure: Overview of secondary storage, RAID and flash storage, indexing (tree, hash, and bitmap), implementation of relational operators; Transaction management: ACID properties, concurrency control, crash recovery. Introduction to Databases: Concepts, importance, and types; Relational Data Model: Fundamentals, data integrity, normalization; Entity-Relationship (ER) Model; Storage and File structure; Structured Query Language (SQL); Database Design; Database Administration; Transaction management; Database Connectivity and Application Development; NoSQL Databases.

Practical Component: Assignments based on theory.

Textbooks:

- R. Ramakrishnan, J. Geherke, Database Management Systems, Third Edition, McGraw Hill, 2014.
- Elmasri Ramez and Navathe Shamkant, Fundamentals of Database System, Seventh Edition, Pearson Education, 2017.

References:

- H. Garcia-Molina, J. Ullman, J. Widom, Database System: The Complete Book, Second Edition, Pearson, 2013.
- P. Bailis, J. Hellerstein, M. Stonebraker, Readings in Database Systems, Fifth Edition, 2015.

DA202 - Java Programming

Credits: 2-0-4-8 | **Pre-requisite:** None

Syllabus:
Introduction: Overview of Java programming language, Setting up Java Development Environment, Basic syntax and structure of Java programs; Data Types and Variables; Type conversion and casting; Control Flow Statements; Looping statements; Methods and Functions, Object-Oriented Programming (OOP) Concepts; Exception handling; Collections framework; File handling; Data Structures: Arrays and multidimensional arrays, Linked lists, stacks, and queues, Trees and graphs; GUI Programming; Database Connectivity; Multithreading; Networking; Data Science and AI Libraries.

Textbooks:

- Herbert Schildt, Java: The Complete Reference, Eleventh Edition, McGraw-Hill Education, 2019.

References:

- David Kopec, Classic Computer Science Problems in Java, First Edition, Manning, 2021.

DA203 - Optimization

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Introduction: Optimization problems and existence of optimal solutions, convex sets and convex functions; Unconstrained optimization: Basic properties of solutions and algorithms, gradient method, Newton's method, quasi-Newton method; Linear optimization: Simplex algorithm, duality; Constrained optimization: Equality and inequality constraints, projected gradient method; Convex optimization.

Textbooks:

- Edwin K. P. Chong & Stanislaw H. Zak, An Introduction To Optimization, Fourth Edition, Wiley India, 2017.

References:

- S. Boyd and L. Vandenberghe, Convex Optimization, First Edition, Cambridge India, 2004.

DA204 - Basic Econometrics

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Brief review of random variables: expectation, variance, covariance, estimation and inference in the context of economics; Classical Linear Regression Model: least squares estimation, unbiasedness and efficiency, Gauss-Markov theorem, hypothesis testing, goodness of fit; Nonlinear models, Dummy variables; Heteroscadasticity, Autocorrelation and Multicollinearity: detection, implications and possible remedies; Omitted variable, measurement errors and instrumental variables; Binary response model, Sample selection problem.

Textbooks:

- Jeffrey M. Wooldridge, Introductory Econometrics: A Modern Approach, Seventh Edition, South-Western College Publishing, 2020.

References:

- Russell Davidson and James Mackinnon, Econometric Theory and Methods, Revised Edition, Oxford University Press, 2009.

DA205 - Data Mining and Warehousing

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Introduction: Definitions, Review of basics of data analysis, applications; Data Warehousing: Definition, architectures, dimensional modeling and star schema, ETL (extract, transform, load) processes; Finding Similar Items: Similarity measures and distance metrics, Shingling and locality-sensitive hashing; Frequent Pattern Mining: Itemset, substring, sequence, pattern evaluation and interestingness measures; Graph Mining: Graph data and representations, link analysis, pattern mining, graph clustering techniques; Mining Data Streams: characteristics of data streams, sliding window models, approximate and sketching techniques, change detection and concept drift.

Textbooks:

- Han, Jiawei, Jian Pei, and Hanghang Tong, Data mining: Concepts and Techniques, 4th Edition, Morgan Kaufmann, 2022.
- Robinson, Ian, Jim Webber, and Emil Eifrem, Graph Databases: New Opportunities for Connected Data, 2nd Edition, O'Reilly Media, Inc., 2015.
- Ponniah, Paulraj, Data Warehousing Fundamentals for IT Professionals, 2nd Edition, John Wiley & Sons, 2012.

References:

- Jure Leskovec, Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, 3rd Edition, Cambridge University Press, 2020.
- Kimball, Ralph, and Margy Ross, The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, Wiley, 2013.
- Reis, Joe, and Matt Housley, Fundamentals of Data Engineering, O'Reilly Media, Inc., 2022.

DA206 - Statistical Inferencing

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Principles of point estimation; Properties of estimators: unbiasedness, consistency, sufficiency, mean squared errors; Methods of estimation: least squares estimation, method of moments estimators, maximum likelihood estimators (MLEs), statistical properties of MLEs, Fisher information, Cramer Rao Lower Bound; Confidence intervals, Bootstrap

percentile method; Testing of hypothesis: Binary hypothesis testing, Type-I and type-II errors, power function, likelihood ratio tests, Neyman-Pearson lemma; Significance testing: general approach, generalized likelihood ratio tests; Bayesian vs Classical statistics, Bayesian inference and posterior distribution, Maximum a Posteriori probability rule, Bayesian least means squares estimation.

Textbooks:

- Wasserman, L., All of Statistics: A concise course in statistical inference, First Edition, Springer, New York, 2004.
- Pishro-Nik, Hossein, Introduction to Probability, Statistics, and Random processes, First Edition, Kappa Research, LLC, 2014.

References:

- Dimitri P. Bertsekas, John N. Tsitsiklis, Introduction To Probability, Second Edition, Athena Scientific, 2008.

DA207 - Signals and Systems

Credits: 3-0-0-6 | **Pre-requisite:** None

Syllabus:
Introduction to Signals: continuous-time, discrete-time signals, properties of signals and various signal operations; Signal representation: signal space and orthogonal bases, Fourier series representation of continuous-time signals, Fourier transform (FT) and its properties; Sampling theorem: aliasing, signal reconstruction, ideal interpolation; Discrete-time FT, Discrete Fourier Transform (DFT) and its properties; System classification and properties; Linear Time Invariant (LTI) systems; Time-domain representation of LTI systems: Impulse response, convolution and response to arbitrary input; Frequency response of LTI systems.

Textbooks:

- B. P. Lathi, Principles of Linear Systems and Signals, Second Edition, Oxford, 2009.
- H. Hsu and R. Rajan, Signals and Systems, Second Edition, Schaum Series, 2017.

References: To be updated

DA208 - Social Media Tools and Techniques

Credits: 3-0-2-8 | **Pre-requisite:** None

Syllabus:
Fundamentals: Understanding social media contents, frameworks, characteristics,

challenges; Mathematical foundations; Data Crawling: Techniques, policies, ethics, responsibilities; Different APIs of crawling data. Text content analysis: Tokenizer, lemmatization; Heaps law, Zipf law; retrieval models, relevance, ranking; Text Embedding; Feature selection, text classification; Network analytics: fundamentals, centrality, link prediction, community detection; network embedding; Applications: Real world applications of social media data.

Textbooks:

- Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press, 2008.
- Subodha Kumar, Liangfei Qiu, Social Media Analytics and Practical Applications - The Change to the Competition Landscape, First Edition, CRC Press, 2021.

References: To be updated

DA209 - Data Modeling and Visualization

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Trimester-III, Second Year | **Type:** Compulsory

Syllabus:
Understanding Structure of Data: Entities, attributes, relationships, data types, data models basics and types, dataset creation and best practices, data preparation for visualization; Introduction to Visual Perception; Guidelines for data visualization; Coordinate system and color scales; Visualizing Amounts; Visualizing Distributions; Visualizing proportions; Visualizing Associations Among Variables; Visualizing Time Series and trends; Visualizing geospatial data and Uncertainty: Projections; Principles of Figure Design; Advanced Topics: Image file formats, visualization softwares, and storytelling using data.

Textbooks:

- Foxwell, Harry J., Creating Good Data: A Guide to Dataset Structure and Data Representation, First Edition, Apress, Berkeley, 2020.
- Claus O. Wilke, Fundamentals of Data Visualization, First Edition, Shroff/O'Reilly, 2019.
- Jonathan Schwabish, Better Data: A Guide for Scholars, Researchers, and Wonks, First Edition, Columbia University Press, 2021.

References: To be updated

DA210 - Time Series Analysis and Forecasting

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Trimester-III, Second Year | **Type:** Compulsory

Syllabus:
Introduction to time series data: Practical examples, Trend in time series data, Parametric trend, LS estimation, Differencing, Nonparametric methods, Trend and noise, Simple time series models, Analysis objectives; Stationary processes: basic properties, linear processes, ARMA(1,1) process, properties, forecasting stationary time series; ARMA(p,q) models: processes, ACF and PACF, spectral densities, periodogram, time-invariant linear filters, spectral density of an ARMA(p,q) process; Modeling and Forecasting with ARMA(p,q) processes: Yule-Walker estimation, Burg's algorithm, Innovations algorithm, Maximum Likelihood Estimation, Diagnostic checking, Forecasting, Order selection criterion; Nonstationary and seasonal models; Applications and recent developments.

Textbooks:

- Brockwell, Peter J., and Richard A. Davis, Introduction to Time Series and Forecasting, Third Edition, Springer New York, 2002.
- Hyndman, Rob J., and George Athanasopoulos, Forecasting: Principles and Practice, Third Edition, OTexts, 2021.

References:

- Kay, Steven M., Fundamentals of Statistical Signal Processing: Estimation Theory, First Edition, Pearson, 1993.
- Nielsen, Aileen, Practical Time Series Analysis: Prediction with Statistics and Machine Learning, First Edition, O'Reilly Media, 2019.

DA261 - Machine Learning Fundamentals

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Trimester-III, Second Year | **Type:** Compulsory

Syllabus:
Introduction: Supervised and unsupervised learning, Generative and discriminative models, Concept of dimensionality and feature vectors, Multi-dimensional Gaussian distribution, Mean vector and covariance matrix in Gaussian distribution; Supervised Learning: Bayesian classification principles, Computation of decision surfaces, Error calculation and performance measures, Risk minimization strategies, Zero-one loss function, Maximum Likelihood Estimation and Maximum A Posteriori Estimation, Bayesian learning concepts, Parzen windows and k-nearest neighbor algorithm, Distance measures and Dynamic Time Warping, Decision trees for classification tasks; Unsupervised Learning: K-means clustering, Hierarchical Agglomerative Clustering, Gaussian Mixture Models, Density-Based Spatial Clustering of Applications with Noise; Dimensionality Reduction Techniques: Curse of dimensionality, Applications of Principal Component Analysis and Fisher Discriminant Analysis to classification problems.

Textbooks:

- E. Alpaydin, Introduction to Machine Learning, 3rd Edition, Prentice Hall (India), 2015.

- R. O. Duda, P. E. Hart, D. G. Stork, Pattern Classification, Second Edition, John Wiley & Sons, 2006.

References:

- C. M. Bishop, Pattern Recognition and Machine Learning, Second Edition, Springer, 2011.
- S. O. Haykin, Neural Networks and Learning Machines, Third Edition, Pearson Education, 2016.

DA262 - Recommender Systems

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Trimester-III, Second Year | **Type:** Compulsory

Syllabus:
Introduction to Recommender Systems; Traditional Recommendation Techniques: Nearest neighbor-based, associative rule-based, content-based filtering, collaborative filtering; Matrix Factorization Techniques: Introduction, SVD review, alternating least squares, non-negative matrix factorization; Advanced Recommendation Techniques: Context-aware, hybrid, model-based methods; Evaluation metrics and methodologies; Recommender System Challenges: Cold start problem, data sparsity, scalability, privacy, and explainability; Case Studies and Applications: E-commerce, social media, multimedia, and other domains; Ethical Considerations in recommendation systems.

Textbooks:

- Charu C. Aggarwal, Recommender Systems: The Textbook, First Edition, Springer, 2016.
- Jannach D., Zanker M., and Fel Fering A., Recommender Systems: An Introduction, First Edition, Cambridge University Press, 2011.

References: To be updated

DA301 - Cloud Computing

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Trimester-I, Third Year | **Type:** Compulsory

Syllabus:

Fundamentals: Computer network basics, concepts of distributed systems, overview of cloud computing; Cloud architecture: Service oriented architecture, event driven architecture, cloud software as a service, cloud platform as a service, cloud infrastructure as a service; Cloud computing security and architecture: Confidentiality, integrity, availability, trusted cloud computing, secure execution environments and communications,

micro architectures, identity management and access control, autonomic security; Risks in cloud computing: CIA triad, privacy and compliance risks, threats to infrastructure, data and access control; Virtual machines: Virtualization, resource allocation; Cloud storage: AWS, Azure, Google cloud; Cloud computing applications: Machine learning, big data analytics;

Textbooks:

- N. B. Ruparelia, Cloud Computing, MIT Press, 2023.
- T. Erl and E. B. Monroy, Cloud Computing: Concepts, Technology, Security & Architecture, Pearson, 2nd Edition, 2024.

References:

- T. Velte, T. J. Velte, and R. Elsenpeter, Cloud Computing: A Practical Approach, Tata McGraw-Hill, New Delhi, 2010.

DA302 - Deep Learning Essentials

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Trimester-I, Third Year | **Type:** Compulsory

Syllabus:

Introduction: Engineered and learned features, multilayer perceptron, back-propagation, activation functions, loss functions, computational analysis; Optimization techniques: Gradient descent methods, momentum, RMSProp, Adam; Convolutional Neural Networks (CNNs): Convolution, pooling, backpropagation in CNN, computational analysis; CNN architectures: LeNet, AlexNet, VGGNet, ResNet, GoogLeNet, DenseNet, MobileNet, EfficientNet; Training issues: Early stopping, dropout, batch normalization, instance normalization, group normalization; Sequential modelling: Recurrent neural networks (RNNs), LSTM, attention; Generative models: Autoencoders, generative adversarial networks (GANs);

Textbooks:

- Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016.
- M. A. Nielsen, Neural Networks and Deep Learning, Determination Press, 2015.

References:

- Zhang, Z. C. Lipton, M. Li, and A. J. Smola, Dive into Deep Learning, Cambridge University Press, 2021.
- Y. Bengio, Learning Deep Architectures for AI, Now Publishers Inc., 2009.

Elective Pool

DA354 - AI based Wireless Communication Systems

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Elective | **Type:** Elective

Syllabus:

Wireless Communication Basics: Overview of physical, medium access control, and network layers and their functionalities; AI Basics: Supervised, unsupervised, and reinforcement learning, deep neural networks; AI-based techniques applied to wireless communication: Channel modelling, spectrum sensing, radio resource allocation, energy efficient communications, adaptive modulation, coding and caching; AI use cases: Multiple input multiple output (MIMO) communication and Internet of Things (IoT).

Textbooks:

To be updated.

References:

- Y. Eldar, A. Goldsmith, D. Gündüz, and H. Vincent Poor, Machine Learning and Wireless Communications, Cambridge University Press, 2022.
- F.-L. Luo, Machine Learning for Future Wireless Communications, 1st Edition, Wiley, 2020.
- Z. Qin et al., AI Empowered Wireless Communications: From Bits to Semantics, Proceedings of the IEEE, Vol. 112, No. 7, July 2024.

DA361 - Financial Valuation and Portfolio Analytics

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Elective | **Type:** Elective

Syllabus:

Time Value of Money: Discounting, present and future value, annuity; Valuation of Bonds: Features of bonds, cash flow, pricing, yield; term structure of interest rates; duration and convexity of bonds; Stock Valuation: Methods of valuation of equity, dividend discount models, relative valuation; Efficient Market Hypothesis (EMH); Risk and Returns: Expected return and risk, measures of risk; Portfolio Theory: Portfolio return and risk, multi-asset portfolio, Markowitz’s model, efficient frontier, capital market line;

Performance Analysis; Asset Pricing: Capital Asset Pricing Model (CAPM), pricing using CAPM, implications of CAPM, beta, security market line, arbitrage pricing theory (APT).

Textbooks:

To be updated .

References:

- R. Srivastava and A. Misra, Financial Management, Oxford University Press, 2011.
- M. Capinski and T. Zastawniak, Mathematics for Finance, Springer, 2010.
- J. C. Francis and D. Kim, Modern Portfolio Theory: Foundations, Analysis, and New Developments, 1st Edition, Wiley, 2013.
- J. C. Hull and S. Basu, Options, Futures and Other Derivatives, 11th Edition, Pearson, 2022.

DAO3063 : Leadership Essentials

Credits: 3-0-0-6 | **Pre-requisite:** None **Offered in:** Elective **Type:** Elective

Objectives:

This course aims to equip future managers and leaders with the knowledge, skills, and mindset required to lead individuals and teams effectively in dynamic organizational environments. The course integrates classical leadership theories with contemporary practices, focusing on self-leadership, interpersonal influence, ethical leadership, team leadership, change leadership, and inclusive leadership.

Syllabus:

Introduction to Leadership: Meaning of leadership, leadership vs management, role of leaders; Leadership Theories: Trait, behavioral, and contingency theories; Emotional Intelligence and leadership; Leadership Styles and Approaches: Transformational, Transactional, Authentic, Servant leadership; Leader–Member Exchange (LMX); Leadership in change and crisis; Conflict management by leaders; Developing leadership capability: assessment tools such as 360-degree feedback and leadership inventories; Role of communication in persuasion; Motivation theories and their application by leaders.

Textbooks:

- Northouse, P. G., Leadership: Theory and Practice, 9th Edition, Sage Publications, 2022.
- Yukl, G., Leadership in Organizations, 9th Edition, Pearson, 2020.

References:

- Kouzes, J. M. & Posner, B. Z., The Leadership Challenge, Wiley, 2017.
- Mintzberg, H., Simply Managing, Berrett-Koehler, 2009.
- Bass, B. M. & Riggio, R., Transformational Leadership, Psychology Press, 2012.
- Goleman, D., Emotional Intelligence, Bantam Books, 2006.

DAO3062 - Data Driven Digital Manufacturing

Credits: 3-0-0-6 | **Pre-requisite:** None | **Offered in:** Elective | **Type:** Elective

Objectives:

This course introduces the fundamental principles, process classifications, materials, and applications of 3D printing technologies. Emphasis is placed on understanding machine architectures, process parameters, and design considerations for different materials and systems. Each module links core 3D printing concepts to their AI-enabled extensions, ranging from geometry generation and slicing to defect prediction and design automation.

Syllabus:

Introduction to 3D printing and opportunities for data science and AI; Computer-aided process planning for 3D printing; Liquid-based 3D printing technologies; Sheet-based 3D printing technologies; Wire-based 3D printing technologies; Powder-based 3D printing technologies; Hybrid 3D printing technologies; Opportunities for digital twins; Predictive maintenance; Intelligent process planning through AI-assisted decision frameworks.

Textbooks:

- L. Jyothish Kumar, Pulak M. Pandey, and David Ian Wimpenny (eds.), 3D Printing and Additive Manufacturing Technologies, Springer, Singapore, 2019.
- Ian Gibson, David Rosen, and Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, New York, NY, 2015.Ian Gibson et al., Additive Manufacturing Technologies, Springer, 2015.

References:

- Patri K. Venuvinod and Weiyin Ma, Rapid Prototyping: Laser-Based and Other Technologies, Springer Science & Business Media, 2013.
- Paul F. Jacobs, Fundamentals of Stereolithography, In Proceedings of the International Solid Freeform Fabrication Symposium, 1992.

DAO3021 - Hardware-Aware Deep Learning

Credits: 3-0-0-6 | **Pre-requisite:** DA261 / DAO2061 Machine Learning Fundamentals (Trimester 3, Year 2 B.Sc. (Honours) Degree Program) **Offered in:** Elective | **Type:** Elective

Objectives:

A significant gap exists between deep learning models and their practical deployment. In real-world settings, beyond selecting appropriate architectures and datasets for training, models are modified in various ways to achieve efficiency goals such as speed, memory usage, and energy consumption. This course focuses on bridging the gap between deep learning theory and its efficient implementation on modern hardware platforms.

- Gain an understanding of hardware deployment of deep learning models.
- Gain an understanding of deep learning hardware architectures.
- Understand efficiency-oriented techniques and their trade-offs.

Syllabus:

Deep learning refresher: non-convex optimization, backpropagation; Automatic differentiation; Neural network library abstractions; Introduction to parallel programming; Deep learning hardware: parallelism in data and hardware, CPUs vs GPUs vs microcontrollers, hardware selection, modern hardware, learning on multiple machines, asynchronous parallelism, decentralized and local stochastic gradient descent; Deep learning inference: sparsity and pruning, quantization, knowledge distillation, fine-tuning, neural architecture search; Training large models; Generative models implementation; Post-training optimizations: parameter-efficient fine-tuning.

Textbooks:

- Andres Rodriguez, Deep Learning Systems: Algorithms, Compilers, and Processors for Large-Scale Production, 1st Edition, Morgan & Claypool Publishers, 2021.
- Simon J. D. Prince, Understanding Deep Learning, 1st Edition, The MIT Press, 2023.

References:

- Geoff Hulten, Building Intelligent Systems: A Guide to Machine Learning Engineering, 1st Edition, Apress, 2018.

DA326 - Deep Learning for Computer Vision

Credits: 3-0-0-6 | **Pre-requisite:** DA302 Deep Learning Essentials (3-0-0-6) | **Offered in:** Elective | **Type:** Elective

Objectives:

This course provides an in-depth understanding of advanced topics in deep learning for computer vision. Students revisit the fundamental building blocks of convolutional neural networks and encoder–decoder architectures, and explore attention mechanisms, transformer networks, and generative models. The course also introduces cutting-edge algorithms, enabling students to design, implement, and optimize state-of-the-art deep learning models for a wide range of computer vision applications.

Syllabus:

Introduction: review of image processing basics; Revisiting convolutional neural networks (CNNs): building blocks of CNNs, backpropagation, encoder–decoder models; CNNs for vision tasks: detection, recognition, segmentation, inpainting, super-resolution, depth estimation, deepfakes; CNN and recurrent neural network (RNN) models for video understanding; Attention models: vision and language, image captioning, visual question answering (VQA); Transformer networks: multi-headed self-attention, cross-attention; Deep generative models: generative adversarial networks (GANs), variants of GANs, variational autoencoders (VAEs); Recent trends: zero-shot, one-shot, few-shot learning, self-supervised learning, meta-learning, transfer learning, and knowledge distillation in vision.

Textbooks:

- R. Szeliski, Computer Vision: Algorithms and Applications, 2nd Edition, Springer, 2022.
- Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016.

References:

- Y. Bengio, Learning Deep Architectures for AI, Now Publishers Inc., 2009.
- Zhang, Z. C. Lipton, M. Li, and A. J. Smola, Dive into Deep Learning, Cambridge University Press, 2021.
