Program Structure for Fourth Year AI&DS

(With Effect from 2023-2024)

Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
ADC801	Advanced Artificial Intelligence	3	--	3	--	3
ADDO 801X	Department Level Optional Course-5	3	--	3	--	3
ADDO 802X	Department Level OptionalCourse-6	3	--	3	--	3
ILO 801X	Institute Level OptionalCourse-2	3	--	3	--	3
ADL801	Advanced Artificial Intelligence Lab	--	2	--	1	1
ADDOL 801X	Department Level Optional Course-5 Lab	--	2	--	1	1
ADDOL 802X	Department Level Optional Course-6 Lab	--	2	--	1	1
ADP801	Major Project-2	--	12#	--	6	6
Total		**12**	**18**	**12**	**9**	**21**

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract.	Total
		Internal Assessment		End Sem Exam	Exam Duration (in Hrs)			
		Mid Test	CA*					
ADC801	Advanced Artificial Intelligence	20	20	60	2	--	--	100
ADDO 801X	Department Level Optional Course -5	20	20	60	2	--	--	100
ADDO 802X	Department Level Optional Course -6	20	20	60	2	--	--	100
ILO 801X	Institute Level Optional Course-2	20	20	60	2	--	--	100
ADL801	Advanced Artificial Intelligence Lab	--	--	--	--	25	25	50
ADDOL 801X	Department Level Optional Course -5 Lab	--	--	--	--	25	25	50
ADDOL 802X	Department Level Optional Course -6 Lab					25	25	50
ADP801	Major Project 2	--	--	--	--	75	75	150
Total		**--**	**--**	**400**	**--**	**150**	**150**	**700**

Major Project 1 and 2 :

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

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

UNIVERSITY OF MUMBAI (With Effect from 2023-2024)

Department and Institute Optional Courses and Labs

Semester	**Department/ Institute Optional Courses and Labs**	**Subject and Labs**
VIII	Department Optional Course -5	ADDO8011: AI for financial & Banking application ADDO8012: Quantum Computing ADDO8013: Reinforcement Learning
	Department Optional Lab -5	ADDOL8011: AI for financial & Banking application Lab ADDOL8012: Quantum Computing Lab ADDOL8013: Reinforcement Learning Lab
	Department Optional Course -6	ADDO8021: Graph Data Science ADDO8022: Recommendation Systems ADDO8023: Social Media Analytics
	Department Optional Lab -6	ADDOL8021: Graph Data Science Lab ADDOL8022: Recommendation Systems Lab ADDOL8023: Social Media Analytics Lab
	Institute level Optional Courses-II	ILO8021: Project Management ILO8022: Finance Management ILO8023: Entrepreneurship Development and Management ILO8024: Human Resource Management ILO8025: Professional Ethics and CSR ILO8026: Research Methodology ILO8027: IPR and Patenting ILO8028: Digital Business Management ILO8029: Environmental Management

Course Code	Course Title	Credit
ADSC801	Advanced Artificial Intelligence	3

Prerequisite: Engineering Mathematics, Data Structures and Algorithm, Python Programming	
Course Objectives:	
1	To relate with the basic concepts of Probabilistic Models.
2	To understand the scope of Generative Networks in the field of AI.
3	To recognize various components of Autoencoder Architecture and Training process.
4	To learn the fundamentals of Transfer Learning.
5	Provide students with a comprehensive understanding of ensemble methods and their applications.
6	To explore the nascent applications of AI
Course Outcomes: After successful completion of the course student will be able to	
1	Acquire basic knowledge of Probabilistic Models.
2	Analyze the working and architecture for Generative Networks.
3	Interpret various components and various types of Autoencoders
4	Understand various aspects of Transfer Learning.
5	Apply ensemble learning techniques to real-world problems and demonstrate improved predictive performance.
6	Relate to the nascent technologies in the field of artificial intelligence.

Module		Content	Hrs
1		**Generative and Probabilistic Models**	**08**
	1.1	**Introduction:** Overview of generative models and their importance in AI, Fundamentals of Probability theory and generative modeling, Introduction to GANs, VAEs and other generative models. Significance of generative models, Challenges with generative models.	
	1.2	**Probabilistic Models:** Gaussian Mixture Models (GMMs), Hidden Markov Models (HMMs), Bayesian Networks, Markov Random Field (MRFs), Probabilistic Graphical Model.	
2		**Generative Adversarial Network**	**07**
	2.1	**Basics of GAN :** Generative Adversarial Networks (GANs) architecture, The discriminator model and generator model, Architecture and Training GANs, Vanilla GAN Architecture. GAN variants and improvements (DCGAN, WGAN, Conditional GAN, CycleGAN), Challenges- Training instability and model collapse, GAN applications in image synthesis and style transfer.	

3		**Variational Autoencoders**	**07**
	3.1 **3.2**	**Introduction:** Basic components of Variational Autoencoders(VAEs), Architecture and training of VAEs the loss function, Latent space representation and inference, Applications of VAEs in image generation. **Types of Autoencoders:** Undercomplete autoencoders, Sparse autoencoders, Contractive autoencoders, Denoising autoencoders, Variational Autoencoders (for generative modelling)	
4		**Transfer Learning**	**05**
	4.1	**Introduction to transfer learning** Basic terminologies, Pre-trained model and data sets, Feature extraction and fine tune transfer learning , Recent advancement in transfer learning : self- supervised learning and meta learning.	
5		**Ensemble learning**	**06**
	5.1	**Ensemble Classifiers**: Introduction to Ensemble Methods. Bagging and random forests, Boosting algorithms : AdaBoost Stacking and blending models, Extreme Gradient Boosting (XGBoost): XGBoost Regression and classification.	
6		**Nascent Technologies in AI**	**06**
	6.1	**Convergence of AI with Augmented / virtual reality techniques for product and process development** Limitations of 2D Learning Environments, Evolution of virtual worlds and immersive technologies, Definition and concepts of Augmented Reality, Definition and concept of the Metaverse, Characteristics and components of the Metaverse, Challenges and opportunities in the Metaverse ecosystem, AI in the realm of emerging quantum computing	

Textbooks:	
1	Foster, D., 2022. *Generative deep learning*. " O'Reilly Media, Inc.".
2	Koller, D. and Friedman, N., 2009. *Probabilistic graphical models: principles and techniques*. MIT press
3	Goodfellow, I., 2016. Deep Learning-Ian Goodfellow, Yoshua Bengio, Aaron Courville- Google Books
4	Murphy, K.P., 2012. *Machine learning: a probabilistic perspective*. MIT press
5	Zhou, Z.H., 2012. *Ensemble methods: foundations and algorithms*. CRC press.

References:	
1	Xiong, J., Hsiang, E.L., He, Z., Zhan, T. and Wu, S.T., 2021. Augmented reality and virtual reality displays: emerging technologies and future perspectives. *Light: Science & Applications*, *10*(1), p.216.
2	Mystakidis, S., 2022. Metaverse. *Encyclopedia*, *2*(1), pp.486-497
3	Gill, S.S., Xu, M., Ottaviani, C., Patros, P., Bahsoon, R., Shaghaghi, A., Golec, M., Stankovski, V., Wu, H., Abraham, A. and Singh, M., 2022. AI for next generation computing: Emerging trends and future directions. *Internet of Things*, *19*, p.100514
4	Mangini, S., Tacchino, F., Gerace, D., Bajoni, D. and Macchiavello, C., 2021. Quantum computing models for artificial neural networks. *Europhysics Letters*, *134*(1), p.10002.

Digital References:	
1	https://nptel.ac.in/courses/106106201
2	https://onlinecourses.nptel.ac.in/noc20_cs62/preview
3	https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

Continuous Assessment:-

Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr.no	Rubrics	Marks
1.	*Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Content beyond syllabus presentation	10 marks
3.	Creating Proof of concept	10 marks
4.	Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion	10 marks
5.	Multiple Choice Questions (Quiz)	5 marks
6.	GATE Based Assignment /Tutorials etc	10 marks

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five needs to be solved.

Course Code	Course Name	Total
ADDO8011	AI for financial & Banking application	03

Course Objectives	
1	To understand the impact of technology and digitization on financial and banking enterprises.
2	To explore blockchain technologies in the financial sector.
3	To examine digital money transfer mechanisms and GIFT cities.
4	To evaluate the benefits of digitization and cloud services in banking.
5	To analyze enterprise software solutions for financial operations.
6	To study the integration of AI in banking processes

Course Outcomes	
On successful completion, of course, learner/student will be able to:	
1	Gain knowledge of technology's influence on financial and banking enterprises.
2	Understand the applications of blockchain in the financial sector.
3	Recognize digital money transfer mechanisms and its role in digitization
4	Evaluate the advantages of digitization and cloud services in banking.
5	Analyze enterprise software solutions for financial operations.
6	Explore the integration of AI in banking processes.

Sr. No.	Content	Hrs.
1	**Information Technology Infrastructureand Digitization of Financial Banking Enterprises** Digital Technology driven processes, Blockchain technologies for Financial – Banking sector, GIFT cities Digital Money transfer Mechanisms. Digitization/ cloud services and solutions in banking and financial services Profiling enterprise software's in financial and banking enterprises.Building Efficiencies, productivity, and infallibility in financial & Banking operations. Detailed study of various processes which shall be transformed by AI integration in banking and financial services. Self-learning : Introduction to business efficiencies, industrial productivity and high degree reliability systems for competitive advantage and carbon neutral enterprises.	04

2	**Financial Statistics and The Sharpe Ratio** Probability, Combinatorics, Mathematical Expectation ,Sample Mean, Standard Deviation, and Variance ,Sample Skewness and Kurtosis ,Sample Covariance and Correlation ,Financial Returns ,Capital Asset Pricing Model ,Sharpe Ratio Formula, Time Periods and Annualizing, Ranking Investment Candidates, The Quantmod Package, Measuring Income Statement Growth, Sharpe Ratios for Income Statement Growth	**07**
3	**Cluster Analysis** K-Means Clustering, Dissecting the K-Means Algorithm Sparsity and Connectedness of Undirected Graph Covariance and Precision Matrices, Visualizing Covariance, The Wishart distribution Glasso Penalization for Undirected Graphs, Running the Glasso Algorithm, Tracking a Value Stock through the Years Regression on Yearly Sparsity , Regression on Quarterly Sparsity , Regression on Monthly Sparsity	**07**
4	**Gauging the Market Sentiment** Markov Regime Switching Model, Reading the Market Data, Bayesian Reasoning, The Beta Distribution , Prior and Posterior Distributions , Examining Log Returns for Correlation ,Momentum Graphs ,Simulating Trading Strategies , Foreign Exchange Markets , Chart Analytics Initialization and Finalization , Momentum Indicators , Bayesian Reasoning within Positions , Entries , Exils ,Profitability,, Short-Term Volatility, The State Machine	**07**
5	**Trading algorithms** Vectorized Backtesting, Backtesting an SMA-Based Strategy, Backtesting a Daily DNN-Based Strategy Backtesting an Intraday DNN-Based Strategy , Risk Management : Trading Bot , Vectorized Backtesting Event-Based Backtesting ,Assessing Risk , Backtesting Risk Measures , Stop Loss , Trailing Stop Loss , Take Profit	**07**
6	**Fraud Analytics** Introduction , The Analytical Fraud Model Life Cycle , Model Representation , Traffic Light Indicator Approach ,Decision Tables , Selecting the Sample to Investigate ,Fraud Alert and Case Management ,Visual Analytics ,Backtesting Analytical Fraud Models : Backtesting Data Stability ,Backtesting Model Stability ,Backtesting Model Calibration , Model Design and Documentation	**07**

Textbooks:	
1	Financial Analytics with R Building a Laptop Laboratory for Data Science MARK J. BENNETT University of Chicago DIRK L. HUGEN University of Iowa
2	Artificial Intelligence in Finance A Python-Based Guide, Yves Hilpisch A
3	Fraud Analytics Using Descriptive, Predictive, and Social Network Techniques: A Guide to Data Science for Fraud Detection, Bart Baesens, Veronique Van Vlasselaer, Wouter Verbeke

References:	
1	" Machine Learning for Asset Managers" by Marcos López de Prado
2	"Advances in Financial Machine Learning" by Marcos López de Prado.

Digital References:

1.	https://www.eastnets.com/newsroom/digital-transformation-in-the-banking-and-financial-services-sector
2.	https://www.techopedia.com/definition/34633/generative-ai

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5.	Multiple Choice Questions (Quiz)	5 marks
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Course Code	Course Title	Credit
ADDO8012	Quantum Computing	3

Prerequisite: Engineering Mathematics, Data Structures and Algorithm, Python Programming			
Course Objectives:			
1	To understand basics of quantum computing		
2	To understand mathematics required for quantum computing		
3	To understand building blocks of quantum computing and design algorithms		
4	To understand quantum hardware principles and tools for quantum computing.		
Course Outcomes: After successful completion of the course student will be able to			
1	Understand basic concepts of quantum computing		
2	Illustrate building blocks of quantum computing through architecture and programming models.		
3	Appraise various mathematical models required for quantum computing		
4	Discuss various quantum hardware building principles.		
5	Identify the various quantum algorithms		
6	Describe usage of tools for quantum computing.		
Module		**Content**	**Hrs**
1.0		**Introduction to Quantum Computing**	**7**
	1.1	Motivation for studying Quantum Computing Origin of Quantum Computing Quantum Computer vs. Classical Computer Introduction to Quantum mechanics Overview of major concepts in Quantum Computing	
	1.2	Qubits and multi-qubits states Bloch Sphere representation Quantum Superposition Quantum Entanglement Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.)	
2.0		**Mathematical Foundations for Quantum Computing**	**05**
	2.1	Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigen values and Eigen vectors.	
3.0		**Building Blocks for Quantum Program**	**08**

	3.1	Architecture of a Quantum Computing platform Details of q-bit system of information representation: Block Sphere Multi-qubits States Quantum superposition of qubits (valid and invalid superposition) Quantum Entanglement Useful states from quantum algorithmic perceptive e.g. Bell State Operation on qubits: Measuring and transforming using gates. Quantum Logic gates and Circuit No Cloning Theorem and Teleportation	
	3.2	Programming model for a Quantum Computing Program Steps performed on classical computer Steps performed on Quantum Computer Moving data between bits and qubits.	
4.0		**Quantum Algorithms and Error correction**	**06**
	4.1	Quantum Algorithms, Shor‘s Algorithm, Grover‘s Algorithm. Deutsch‘s Algorithm, Deutsch -Jozsa Algorithm	
	4.2	Quantum error correction using repetition codes 3 qubit codes, Shor‘s 9 qubit error correction Code	
5.0		**Quantum Hardware**	**10**
	5.1	Ion Trap Qubits ,The DiVincenzo Criteria , Lagrangian and Hamiltonian Dynamics in a Nutshell: Dynamics of a Translating	
	5.2	Rotor Quantum Mechanics of a Free Rotor: A Poor Person‘s Atomic	
	5.3	Model: Rotor Dynamics and the Hadamard Gate, Two-Qubit Gates The Cirac-Zoller Mechanism: Quantum Theory of Simple Harmonic Motion, A Phonon-Qubit Pair Hamiltonian, Light-Induced Rotor-Phonon Interactions, Trapped Ion Qubits, Mølmer-Sørenson Coupling ..	
	5.4	Cavity Quantum Electrodynamics (cQED): Eigenstates of the Jaynes-Cummings Hamiltonian Circuit QED (cirQED): Quantum LC Circuits, Artificial Atoms, Superconducting Qubits Quantum computing with spins: Quantum inverter realized with two exchange coupled spins in quantum dots, A 2-qubit spintronic universal quantum gate.	
6.0		**OSS Toolkits for implementing Quantum program**	**03**
	6.1	IBM quantum experience Microsoft Q Rigetti PyQuil (QPU/QVM)	

Textbooks:	
1	Michael A. Nielsen, ―Quantum Computation and Quantum Information‖, Cambridge University Press.
2	David McMahon, ―Quantum Computing Explained‖, Wiley ,2008
3	Qiskit textbook https://qiskit.org/textbook-beta/
4	Vladimir Silva, Practical Quantum Computing for Developers,2018

References:	
1	Bernard Zygelman, A First Introduction to Quantum Computing and Information,2018
2	Supriyo Bandopadhyay and Marc Cahy, ―Introduction to Spintronics‖, CRC Press, 2008
3	The Second Quantum Revolution: From Entanglement to Quantum Computing and Other Super-Technologies, Lars Jaeger
4	La Guardia, Giuliano Gladioli ―Quantum Error correction codes‖Springer,2021
Digital References:	
1	https://onlinecourses.nptel.ac.in/noc21_cs103/preview
2	https://www.coursera.org/courses?query=quantum%20computing
3	https://www.cl.cam.ac.uk/teaching/1617/QuantComp/

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Course Code:	Course Title	Credit
ADDO8013	Reinforcement Learning	3

Module	Content	Hours
0	**Prerequisite**	02
	Probability distributions and expected values, and basic linear algebra (e.g., inner products).	
1	**Introduction to Reinforcement Learning:**	04
	Reinforcement Learning: Key features and Elements of RL, Types of RL, rewards. Reinforcement Learning Algorithms: Q-Learning, State Action Reward State action (SARSA),	
2	Bandit problems and online learning:	07
	An n-Armed Bandit Problem, Action-Value Methods Tracking a Nonstationary Problem, Optimistic Initial Values Upper-Confidence-Bound Action Selection Gradient Bandits	
3	Markov Decision Processes:	07
	The Agent–Environment Interface, The Agent–Environment Interface, Goals and Rewards, Returns, Markov properties, Markov Decision Process, Value Functions and Optimal Value Functions,	
4	Dynamic Programming:	07
	Policy Evaluation (Prediction), Policy Improvement, Policy Iteration, Value Iteration, Asynchronous Dynamic Programming, Generalized Policy Iteration	
5	Monte Carlo Methods and Temporal-Difference Learning	07
	Monte Carlo Prediction, Monte Carlo Estimation of Action Values, Monte Carlo Control, TD Prediction, TD control using Q-Learning	
6	Applications and Case Studies	05
	Elevator Dispatching, Dynamic Channel Allocation, Job-Shop Scheduling	

Text Books:	
1	Reinforcement Learning: An Introduction, by Richard S. Sutton and Andrew G. Barto
2	Alessandro Palmas, Dr. Alexandra Galina Petre, Emanuele Ghelfi, The Reinforcement Learning Workshop: Learn how to Apply Cutting-edge Reinforcement Learning Algorithms to a Wide Range of Control Problems, 2020 Packt publishing.
3	Phil Winder, Reinforcement Learning Industrial Applications with Intelligent Agents, O'Reilly
4	Dr Engr S M Farrukh Akhtar, Practical Reinforcement Learning, Packt Publishing, 2017.

References Books:	
1	Maxim Lapan, Deep Reinforcement Learning Hands-On: Apply modern RL methods, with deep Q-networks, value iteration, policy gradients, TRPO, AlphaGo Zero.
2	Csaba Szepesv´ari, Algorithms for Reinforcement Learning, Morgan & Claypool Publishers
3	Alberto Leon-Garcia, Probability, Statistics and Random Processes for Electrical Engineering, Third Edition, Pearson Education, Inc.

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Course Code	Course Name	Credit
ADDO8021	Graph Data Science	03

Course Objectives:	
1	To Understand the basics of graphs, including definitions, connectivity, and properties.
2	To Explore the use of graphs in solving puzzles and optimization problems.
3	To Learn about the advantages of graph databases over relational and NoSQL databases.
4	To Gain knowledge of data modeling with graphs, including the labeled property graph model.
5	To Develop skills in building graph database applications, including data modeling and testing.
6	To Explore real-world use cases and understand non-functional characteristics of graph databases.

Course Outcomes:	
On successful completion, of course, learner/student will be able to:	
1	Demonstrate a solid understanding of graph concepts and properties.
2	Apply graph algorithms to solve puzzles and optimization problems.
3	Compare graph databases with relational and NoSQL databases.
4	Model data using the labeled property graph model and avoid common pitfalls.
5	Build graph database applications with proper data modeling and testing.
6	Analyze and implement graph database solutions for real-world use cases, considering non-functional characteristics

Module	Content	Hours
1	**Introduction to Graph**	04
	Definitions and examples, Three puzzles, Paths and cycles, Connectivity, Eulerian graphs, Hamiltonian graphs, shortest path, Chinese postman problem, traveling salesman problem, trees, properties of trees	
2	**Introduction Graph databases**	07
	A High-Level View of the Graph Space, Graph Databases, Graph Compute Engines, The Power of Graph Databases, Performance, Flexibility, Agility, Options for Storing Connected Data, Relational Databases Lack Relationships, NOSQL Databases Also Lack Relationships, Graph databases embraces relationship	
3	**Data Modelling with Graphs**	07
	Models and Goals, The Labelled Property Graph Mode Querying Graphs, A Comparison of Relational and Graph Modelling, Cross-Domain Models, Common Modelling Pitfalls, Identifying Nodes and Relationships, Avoiding Anti-Patterns	
4	**Building a Graph Database Application**	07
	Data Modelling, Application Architecture, Testing , Capacity Planning, Importing and Bulk Loading Data,	
5	**Graphs in the Real-World**	07

	Organizations Choose Graph Databases, Common Use Cases, Real-World Examples, Authorization and Access Control, Geospatial and Logistics, Graph Database Internals, Native Graph Processing, Native Graph Storage Programmatic APIs, Kernel API, Core API, Traversa Framework, Non-functional Characteristics	
6	**Case Study**	**07**
	Neo4j – About, Neo4j – Installation, Neo4j – Browser Neo4j - Query Language (Cypher), Neo4j - Create a Node Neo4j - Create Relationship, Neo4j - Create an Index Neo4j - Create a Constraint, Neo4j - Select Data with MATCH, Neo4j - Import Data from CSV, Neo4j - Drop an Index, Neo4j - Drop a Constraint, Neo4j - Delete a Node, Neo4j - Delete a Relationship	

Textbooks:	
1	Introduction to Graph Theory Fourth edition, Robin J. Wilson
2	Daphne Koller and Nir Friedman, "Probabilistic Graphical Models: Principles and Techniques", Cambridge, MA: The MIT Press, 2009 (ISBN 978-0-262-0139- 2).
3	Graph databases, Ian Robinson, Jim Webber & Emil Eifrem

References:	
1	"Graph Databases: New Opportunities for Connected Data" by Ian Robinson, Jim Webber, and Emil Eifrém.
2	"Neo4j in Action" by Aleksa Vukotic, Nicki Watt, and Tareq Abedrabbo.
3	"Graph Databases for Beginners" by Mark Needham and Amy E. Hodler.
4	"Practical Neo4j" by Gregory Jordan.
5	"Learning Neo4j" by Rik Van Bruggen.
6	"Graph Database Applications and Concepts with Neo4j" by Dionysios Synodinos.

Digital References:

1. https://web4.ensiie.fr/~stefania.dumbrava/OReilly_Graph_Databases.pdf
2. https://www.quackit.com/neo4j/tutorial/

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Course Code:	Course Title	Credit
ADDO8022	Recommendation Systems	3

Prerequisite: Artificial Intelligence and Machine Learning, Basic knowledge of Python	
Course Objectives:	
1	To introduce Recommendation systems and it's basic concepts.
2	To understand design and working of Collaborative Filtering based recommendation.
3	To analyze design and working of Content-based recommendation.
4	To understand design and working of Knowledge based recommendation.
5	To understand design and working of Ensembled- Based and Hybrid Recommendation Systems.
6	To identify the methods for evaluation of recommendation systems.
Course Outcomes: After successful completion of the course student will be able to	
1	To have a broad understanding of the field of Recommendation Systems.
2	In-depth Knowledge of the architecture and models for Collaborative Filtering.
3	Understanding the architecture and working of Content based recommendation systems.
4	Understanding the architecture and basics of Knowledge based recommendation systems.
5	Analyzing hybrid and ensembles recommendation systems.
6	Evaluation of recommendation systems by selecting right evaluation parameter.

Module		Content	Hrs
1.0		**Introduction to Recommendation System**	**06**
	1.1	History of recommendation system, Eliciting Ratings and other Feedback Contributions, Implicit and Implicit Ratings, Recommender system functions.	
	1.2	Linear Algebra notation: Matrix addition, Multiplication, transposition, and inverses; covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system.	
2.0		**Collaborative Filtering**	**06**
	2.1	Architecture of Collaborative Filtering, User-based nearest neighbour recommendation, Item-based nearest neighbour recommendation, Model based and pre-processing based approaches, Clustering for recommendation system, Attacks on collaborative recommender systems, Advantages and drawbacks of Collaborative Filtering.	

3.0		**Content-based recommendation**	**07**
	3.1	Architecture of content-based systems, Content representation and content similarity, Item profiles, Discovering features of documents, Obtaining item features from tags, Representing item profiles, Methods for learning user profiles, Similarity based retrieval, The Role of User Generated Content in the Recommendation Process.	
	3.2	Bayes classifier for recommendation, Regression based recommendation system. Advantages and drawbacks of content-based filtering	
4.0		**Knowledge based recommendation**	**06**
	4.1	Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders, Persistent Personalization in Knowledge-Based Systems, Conversational Recommendation. Search based recommendation, Navigation-based recommendation.	
5.0		**Ensembled- Based and Hybrid Recommendation System**	**06**
	5.1	Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies.	
6.0		**Evaluating Recommendation System**	**08**
	6.1	Characteristics and properties of evaluation research, Evaluation design goals- Accuracy, Coverage, Confidence and Trust, Novelty, Serendipity, Diversity, Robustness, Stability and Scalability.	
	6.2	Comparison between evaluation design of classification model and recommendation system, Error metrics, Decision-Support metrics, User-Centered metrics. Comparative analysis between different types of recommendation systems.	

Textbooks:	
1	Jannach, D., Zanker, M., Felfernig, A., & Friedrich, G. (2010). *Recommender systems: an introduction*. Cambridge University Press.
2	Ricci, F., Rokach, L., & Shapira, B. (2011). Introduction to Recommender Systems Handbook. Springer, Boston, MA.
References:	
1	Aggarwal, C. C. (2016). *Recommender systems* (Vol. 1). Cham: Springer International Publishing.

Useful Links:	
1	http://www.iem.iitkgp.ac.in/eco/Recommender_Systems/
2	https://www.coursera.org/specializations/recommender-systems
3	https://www.udemy.com/course/recommender-systems/
4	https://www.analyticsvidhya.com/blog/2021/08/developing-a-course-recommender-system- using-python/

Internal Assessment:
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

Continuous Assessment: -
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr.no	Rubrics	Marks
1	*Certificate course for 4 weeks or more: - NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2	Content beyond syllabus presentation	10 marks
3	Creating Proof of concept	10 marks
4	Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion	10 marks
5	Multiple Choice Questions (Quiz)	5 marks
6	GATE Based Assignment/Tutorials etc	10 marks

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five needs to be solved.

Course Code	Course Name	Credit
ADDO8023	Social Media Analytics	03

Prerequisite: Graph Theory, Data Mining, Python/R programming	
Course Objectives: The course aims:	
1	Familiarize the learners with the concept of social media.
2	Familiarize the learners with the concept of social media analytics and understand its significance.
3	Enable the learners to develop skills required for analyzing the effectiveness of social media.
4	Familiarize the learners with different tools of social media analytics.
5	Familiarize the learner with different visualization techniques for Social media analytics.
6	Examine the ethical and legal implications of leveraging social media data.
Course Outcomes:	
1	Understand the concept of Social media
2	Understand the concept of social media Analytics and its significance.
3	Learners will be able to analyze the effectiveness of social media
4	Learners will be able to use different Social media analytics tools effectively and efficiently.
5	Learners will be able to use different effective Visualization techniques to represent social media analytics.
6	Acquire the fundamental perspectives and hands-on skills needed to work with social media data.

Module	Detailed Content	Hrs.
1.	**Social Media Analytics: An Overview**	
	Core Characteristics of Social Media, Types of Social Media, Social media landscape, Need for Social Media Analytics (SMA), SMA in small & large organizations. Purpose of Social Media Analytics, Social Media vs. Traditional Business Analytics, Seven Layers of Social Media Analytics, Types of Social Media Analytics, Social Media Analytics Cycle, Challenges to Social Media Analytics, Social Media Analytics Tools	6
2.	**Social Network Structure, Measures & Visualization**	
	Basics of Social Network Structure - Nodes, Edges & Tie Describing the Networks Measures - Degree Distribution, Density, Connectivity, Centralization, Tie Strength & Trust Network Visualization - Graph Layout, Visualizing Network features, Scale Issues. Social Media Network Analytics - Common Network Terms, Common Social Media Network Types, Types of Networks, Common Network Terminologies, Network Analytics Tools.	6

3.	**Social Media Text, Action & Hyperlink Analytics**	**8**
	Social Media Text Analytics - Types of Social Media Text, Purpose of Text Analytics, Steps in Text Analytics, Social Media Text Analysis Tools Social Media Action Analytics - What Is Actions Analytics? Common Social Media Actions, Actions Analytics Tools Social Media Hyperlink Analytics - Types of Hyperlinks, Types of Hyperlink Analytics, Hyperlink Analytics Tools	
4.	**Social Media Location & Search Engine Analytics**	**6**
	Location Analytics - Sources of Location Data, Categories of Location Analytics, Location Analytics and Privacy Concerns, Location Analytics Tools Search Engine Analytics - Types of Search Engines, Search Engine Analytics, Search Engine Analytics Tools	
5.	**Social Information Filtering**	**6**
	Social Information Filtering - Social Sharing and filtering , Automated Recommendation systems, Traditional Vs social Recommendation Systems Understanding Social Media and Business Alignment, Social Media KPI, Formulating a Social Media Strategy, Managing Social Media Risks	
6.	**Social Media Analytics Applications and Privacy**	**7**
	Social media in public sector - Analyzing public sector social media, analyzing individual users, case study. Business use of Social Media - Measuring success, Interaction and monitoring, case study. Privacy - Privacy policies, data ownership and maintaining privacy online.	

Textbooks:	
1.	Seven Layers of Social Media Analytics_ Mining Business Insights from Social Media Text, Actions, Networks, Hyperlinks, Apps, Search Engine, and Location Data, Gohar F. Khan,(ISBN-10: 1507823207).
2.	Analyzing the Social Web 1st Edition by Jennifer Golbeck
3.	Mining the Social Web_ Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites, Matthew A Russell, O'Reilly
4	Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011
References:	
1.	Social Media Analytics [2015], Techniques and Insights for Extracting Business Value Out of Social Media, Matthew Ganis, AvinashKohirkar, IBM Press
2.	Social Media Analytics Strategy_ Using Data to Optimize Business Performance, Alex Gonçalves, APress Business Team
3.	Social Media Data Mining and Analytics, Szabo, G., G. Polatkan, O. Boykin & A. Chalkiopoulus (2019), Wiley, ISBN 978-1-118-82485-6

Useful Links	
1	https://cse.iitkgp.ac.in/~pawang/courses/SC16.html
2	https://onlinecourses.nptel.ac.in/noc20_cs78/preview
3	https://nptel.ac.in/courses/106106146
4	https://7layersanalytics.com/

Internal Assessment:

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

Continuous Assessment:-

Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

Sr.no	Rubrics	Marks
	*Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC	10 marks
1.	Content beyond syllabus presentation	10 marks
2.	Creating Proof of concept	10 marks
3.	Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion	10 marks
4.	Multiple Choice Questions (Quiz)	5 marks
5.	GATE Based Assignment/Tutorials etc	10 marks

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five needs to be solved.

Course Code:	Course Title	Credit
ADL801	Advanced AI Lab	01

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

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Design and implement a Hidden Markov Models for outcome prediction.
2	Design and implement a Bayesian Network for outcome prediction.
3	Design and implement a Gaussian Mixture Models for outcome prediction.
4	Build and Train a Generative Multi-Layer Network Model using appropriate dataset.
5	Build and Train a Deep Convolution Generative Multi-Layer (DCGAN) Network Model for an image-based dataset.
6	Develop a Conditional GAN (CGAN) Network to direct the image generation process of the generator model.
7	Train a variational autoencoder using Tensorflow on Fashion MNIST

8	Explore the working of any pre-trained model towards outcome generation.
9	Implement and analyze the working of Local Interpretable Model-agnostic Explanations (LIME) supervised model.
10	Case-study on the emerging technologies in AI like Metaverse, Augmented reality etc.
11	Mini Project Report: For any one chosen real world application as per the syllabus of CSC801: Advanced AI.
12	Implementation and Presentation of Mini Project

Useful Links	
1	https://nptel.ac.in/courses/106106224
2	https://www.tensorflow.org/tutorials/generative/cvae
3	https://www.analyticsvidhya.com/blog/2022/07/everything-you-need-to-know-about-lime/
4	https://onlinecourses.nptel.ac.in/noc20_cs62/preview
5	https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/

Term Work:	
1	Term work should consist of 8(min) to 12(max) experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks for Experiments
Evaluation Exam	
Based on the subject and related lab of Adv AI and Theory	

Lab Code	Lab Name	Credit
ADDOL8011	**AI for financial & banking application lab**	**1**

Prerequisite: Python Programming, Deep Learning, Machine Learning.	
Lab Objectives: Students will try	
1	To implement digital money transfer systems in the banking sector.
2	To calculate risk-adjusted performance measures for investment portfolios.
3	To apply cluster analysis to identify patterns in financial data.
4	To analyze market sentiment using the Markov regime switching model.
5	To design and back test trading algorithms for financial markets
6	To detect and prevent fraudulent activities using fraud analytics techniques
Lab Outcomes: At the end of the course, the students will be able to	
1	Proficiency in implementing secure and efficient digital money transfer systems.
2	Ability to assess investment performance using risk-adjusted measures.
3	Competence in identifying meaningful patterns and segments in financial data.
4	Understanding of market sentiment and its impact on trading decisions.
5	Practical skills in developing and evaluating trading algorithms.
6	Knowledge of fraud detection methods for financial systems.

Suggested Experiments:

Sr. No.	Suggested List of Experiments
1.	Setting up a Digital Money Transfer System
2.	Calculating Sharpe Ratios for Investment Portfolios
3.	Cluster Analysis of Financial Data for Market Segmentation
4.	Analyzing Market Sentiment using the Markov Regime Switching Model
5.	Developing and Backtesting a Simple Trading Algorithm
6.	Implementing Advanced Risk Management Techniques in Trading Algorithms
7.	Fraud Detection using Machine Learning Algorithms
8.	Visualizing Fraud Patterns and Analytics
9.	Designing and Backtesting Complex Trading Strategies
10.	Evaluating and Enhancing the Performance of Trading Algorithms
11.	Applying Machine Learning for Predictive Fraud Analytics

Textbooks:	
1	Financial Analytics with R Building a Laptop Laboratory for Data Science MARK J. BENNETT University of Chicago DIRK L. HUGEN University of Iowa
2	Artificial Intelligence in Finance A Python-Based Guide, Yves Hilpisch A
3	Fraud Analytics Using Descriptive, Predictive, and Social Network Techniques: A Guide to Data Science for Fraud Detection , Bart Baesens, Veronique Van Vlasselaer, Wouter Verbeke

References:	
1	" Machine Learning for Asset Managers" by Marcos López de Prado
2	"Advances in Financial Machine Learning" by Marcos López de Prado.

Digital References:

1.	https://www.eastnets.com/newsroom/digital-transformation-in-the-banking-and-financial-services-sector
2.	https://www.techopedia.com/definition/34633/generative-ai

Term Work:	
1.	Term work should consist of 8(min) to 12(max) experiments.
2.	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3.	Total 25 Marks for Experiments

Evaluation Exam

Based on the subject and related lab of AI for financial & banking application Lab and theory

Lab Code	Lab Name	Credit
ADDOL8012	Quantum Computing Lab	1

Prerequisite: Python Programming Language.	
Lab Objectives:	
1	To implement fundamental quantum computing concepts
2	To learn quantum computation and quantum information
3	To understand quantum entanglement, quantum algorithms
4	To understand quantum information theory and channels
Lab Outcomes: Students will be able to	
1	Implement basic quantum computing logic by building dice and random numbers using open source simulation tools.
2	Understand quantum logic gates using open-source simulation tools.
3	Implement quantum circuits using open-source simulation tools.
4	I implement quantum algorithms using open-source simulation tools.

Suggested Experiments: Students are required to complete at least 10 experiments. Faculty may develop their own set of experiments for students. List below is only suggestive.

Sr. No.	Name of the Experiment
1	Building Quantum dice
2	Building Quantum Random No. Generation
3	Composing simple quantum circuits with q-gates and measuring the output into classical bits.
4	Implementation of Shor ‘s Algorithms
5	Implementation of Grover ‘s Algorithm
6	Implementation of Deutsch ‘s Algorithm
7	Implementation of Deutsch-Jozsa‘s Algorithm
8	Quantum Circuits
9	Qubit Gates
10	Bell Circuit & GHZ Circuit
11	Accuracy of Quantum Phase Estimation
12	Mini Project such as implementing an API for efficient search using Grover ‘s Algorithms or Integer factorization using Shor‘s Algorithm.

Useful Links:	
1	IBM Experience: https://quantum-computing.ibm.com/
2	Microsoft Quantum Development Kit https://azure.microsoft.com/en-us/resources/development-kit/quantum-computing/#overview
3	Forest SDK PyQuil: https://pyquil-docs.rigetti.com/en/stable/
4	Google Quantum CIRQ https://quantumai.google/cirq
5	Qiskit Labs IBM https://learn.qiskit.org/course/ch-labs/lab-1-quantum-circuits

Term Work:	
1.	Term work should consist of 8(min) to 12(max) experiments.
2.	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3.	Total 25 Marks for Experiments
Evaluation Exam	
Based on the subject and related lab of Quantum Computing and theory	

Course Code:	Course Title	Credit
ADDOL8013	Reinforcement Learning Lab	1

Prerequisite: Python Programming, Deep Learning, Machine Learning.	
Lab Objectives: Students will try	
1	Introduce the fundamentals of reinforcement learning and problem formulation using MDPs and Bandit problems
2	Explode different exploration strategies and their impact on online leaning scenarios.
3	Understand dynamic programming algorithms for solving Markov Decision Processes.
4	Apply dynamic programming techniques to solve small-scale MDP problems
5	Implement and compare Monte Carlo methods and Temporal-Difference learning algorithms.
6	Explore real-world applications of reinforcement learning in domains such as autonomous driving or robotics
Lab Outcomes: At the end of the course, the students will be able to	
1	Gain a solid understanding of reinforcement learning concepts and problem formulation.
2	Evaluate and compare exploration strategies in online learning scenarios.
3	Solve Markov Decision Processes using dynamic programming algorithms
4	Apply dynamic programming techniques to solve small-scale MDP problems.
5	Implement and analyze Monte Carlo methods and Temporal-Difference learning algorithms
6	Explore practical applications of reinforcement learning in real-world domains.

Sr. No.	Suggested List of Experiments
1.	Implementing a simple grid-world environment and training an agent using basic Q-learning
2.	Implementing a multi-armed bandit problem and comparing different exploration strategies like epsilon-greedy and UCB.
3,	Implementing a basic grid-world environment as an MDP and applying policy iteration and value iteration algorithms to find optimal policies.
4.	Applying dynamic programming algorithms, such as policy evaluation and policy improvement, to solve a small-scale MDP problem.
5.	Implementing Monte Carlo control and Temporal Difference (TD) learning algorithms to train an agent in a grid-world environment.
6.	Exploration vs. Exploitation Trade-off: Experimenting with different exploration strategies and analyzing their impact on the learning performance of an agent in a bandit problem.
7.	Function Approximation in Reinforcement Learning: Using function approximation techniques, such as linear regression or neural networks, to approximate value functions in reinforcement learning problems.

8.	Deep Reinforcement Learning: Implementing a deep Q-network (DQN) to train an agent to play a popular Atari game, such as Pong or Space Invaders.
9.	Transfer Learning and Multi-Task Reinforcement Learning: Investigating transfer learning in reinforcement learning by training an agent in one environment and transferring its knowledge to a different but related environment
10.	Policy Gradient Methods: Implementing policy gradient methods, such as REINFORCE or Proximal Policy Optimization (PPO), to train an agent in a continuous control environment.
*11.	Applications and Case Studies: Applying reinforcement learning techniques to solve a real-world problem, such as training a self-driving car to navigate a simulated road environment.

Textbooks	
1	Reinforcement Learning: An Introduction, by Richard S. Sutton and Andrew G. Barto
2	Alessandro Palmas, Dr. Alexandra Galina Petre, Emanuele Ghelfi, The Reinforcement Learning Workshop: Learn how to Apply Cutting-edge Reinforcement Learning Algorithms to a Wide Range of Control Problems, 2020 Packt publishing.
3	Phil Winder, Reinforcement Learning Industrial Applications with Intelligent Agents, O'Reilly
4	Dr Engr S M Farrukh Akhtar, Practical Reinforcement Learning, Packt Publishing, 2017.
References Books	
1	Maxim Lapan, Deep Reinforcement Learning Hands-On: Apply modern RL methods, with deep Q-networks, value iteration, policy gradients, TRPO, AlphaGo Zero.
2	Csaba Szepesv´ari, Algorithms for Reinforcement Learning, Morgan & Claypool Publishers
3	Alberto Leon-Garcia, Probability, Statistics and Random Processes for Electrical Engineering, Third Edition, Pearson Education, Inc.

Useful Links	
1	Machine Learning and Friends at Carnegie Mellon University
2	Reinforcement Learning: A Survey
3	Bibliography on Reinforcement Learning
4	David J. Finton's Reinforcement Learning Page

Term Work:	
1	Term work should consist of 8(min) to 12(max) experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks for Experiments
Evaluation Exam	
Based on the subject and related lab of **Reinforcement Learning and theory**	

Lab Code	Lab Name	Credit
ADDOL8021	**Graph Data Science Lab**	**1**

Lab Objectives: Students will try	
1	To understand graph database fundamentals and their advantages.
2	To design and implement effective data models using the labeled property graph model.
3	To develop proficiency in querying and analyzing graph data using Cypher.
4	To gain knowledge of graph database administration tasks and data management.
5	To apply graph database techniques to real-world use cases.
6	To develop practical skills in graph database application development.
Lab Outcomes: At the end of the course, the students will be able to	
1	Comprehensive understanding of graph databases and their benefits.
2	Proficiency in creating data models for representing complex relationships.
3	Ability to write efficient queries and analyze graph data effectively.
4	Competence in administering and managing graph databases.
5	Application of graph database techniques to solve real-world problems.
6	Understand developing graph database applications.

Prerequisite: Python Programming, Deep Learning, Machine Learning.

Sr. No.	Suggested List of Experiments
1.	Graph Database Fundamentals: ○ Install and set up a graph database system (e.g., Neo4j) on a local machine. ○ Familiarize yourself with the graph database environment, including the query language (Cypher) and browser interface.

2.	Data Modeling with Graphs: ○ Design a data model using the labeled property graph model for a specific domain (e.g., social network, e-commerce). ○ Implement the data model in the graph database and populate it with sample data.
3.	Basic Graph Queries: ○ Perform basic graph queries using Cypher to retrieve nodes, relationships, and their properties. ○ Explore different query patterns, such as finding paths, filtering nodes, and ordering results.
4.	Advanced Graph Queries: ○ Extend your query knowledge by performing more complex graph queries, including subgraph matching, aggregation, and conditional filtering. ○ Optimize query performance by understanding and utilizing indexes.
5.	Graph Database Administration: ○ Learn and practice essential administrative tasks, such as managing users, roles, and access control. ○ Perform backup and restore operations to ensure data integrity.
6.	Importing and Exporting Data: ○ Import data from external sources (e.g., CSV files) into the graph database. ○ Export graph data to different formats for analysis or sharing.
7.	Graph Algorithms and Analytics: ○ Explore the built-in graph algorithms provided by the graph database system (e.g., centrality, community detection). ○ Apply graph algorithms to analyze and extract insights from your graph data
8.	Graph Visualization and Exploration: ○ Utilize visualization tools and libraries to visualize your graph data. ○ Explore and navigate the graph visually to gain a better understanding of its structure and relationships.
9.	Performance Optimization: ○ Identify and address performance bottlenecks in your graph database application. ○ Optimize queries, indexes, and data modeling to improve overall system

	performance.
10.	Scaling and Replication: ○ Learn techniques for scaling and replicating a graph database to handle larger datasets and higher workloads. ○ Implement and test replication strategies to ensure data availability and fault tolerance.
***11.**	Real-World Use Cases: ○ Choose a specific real-world use case (e.g., recommendation systems, fraud detection) and apply graph database techniques to solve the problem. ○ Design and implement a graph database application that addresses the unique requirements of the chosen use case.

Textbooks:	
1	Introduction to Graph Theory Fourth edition, Robin J. Wilson
2	Daphne Koller and Nir Friedman, "Probabilistic Graphical Models: Principles and Techniques", Cambridge, MA: The MIT Press, 2009 (ISBN 978-0-262-0139- 2).
3	Graph databases, Ian Robinson, Jim Webber & Emil Eifrem

References:	
1	"Graph Databases: New Opportunities for Connected Data" by Ian Robinson, Jim Webber, and Emil Eifrém.
2	"Neo4j in Action" by Aleksa Vukotic, Nicki Watt, and Tareq Abedrabbo.
3	"Graph Databases for Beginners" by Mark Needham and Amy E. Hodler.
4	"Practical Neo4j" by Gregory Jordan.
5	"Learning Neo4j" by Rik Van Bruggen.
6	"Graph Database Applications and Concepts with Neo4j" by Dionysios Synodinos.
Useful Links:	
1.	https://web4.ensiie.fr/~stefania.dumbrava/OReilly_Graph_Databases.pdf
2.	https://www.quackit.com/neo4j/tutorial/

Term Work:	
1	Term work should consist of 8(min) to 12(max) experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks for Experiments
Evaluation Exam	
Based on the subject and related lab of Graph Data Science and Theory	

Course Code:	Course Title	Credit
ADDOL8022	Recommendation Systems Lab	1

Prerequisite: Java/Python	
Lab Objectives:	
1	To understand the key concepts of Recommendation systems.
2	Design and implement cluster-based approaches for recommendation systems.
3	Design, implement and analyze classification algorithms for recommendation systems.
4	To understand various Recommendation system Algorithms.
5	To understand data processing for Recommendation system Algorithms
Lab Outcomes: At the end of the course, the students will be able to	
1	Understand mathematics and representation of data for recommendation systems.
2	Design, implement and analyze Collaborative filtering based for recommendation systems.
3	Design, implement and analyze Content-based recommendation systems.
4	Design, implement and analyze Knowledge-based recommendation systems.
5	Understanding feature engineering and pre-processing for recommendation systems.
6	To solve real world problems using recommendation systems.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Implementation of Matrix operations and data representation towards understanding mathematics for recommendation system
2	Experiment on the role of clustering methods with respect to recommendation systems
3	Feature engineering and pre-processing of data for recommendation systems.
4	Implementation of Bayes classifier for recommendation.
5	Implement User-based Nearest neighbor recommendation.
6	Implement Item-based Nearest neighbor recommendation
7	Implement Content-based recommendation system.
8	Implement Knowledge-based recommendation system.
9	Implementation of a recommendation system using Hybrid approach.
10	Implementation of a recommendation system using Ensembled approach.
11	Implementation of a Regression based recommendation system.

12	Analyze results on the basis of different evaluation parameters and graphical representations for recommendation systems.
13	Mini Project Report: For any one chosen real world Recommendation systems application.
14	Implementation and Presentation of Mini Project

Useful Links	
1	https://towardsdatascience.com/recommendation-systems-explained-a42fc60591ed
2	https://www.coursera.org/specializations/recommender-systems

Term Work:	
1.	Term work should consist of 8(min) to 12(max) experiments.
2.	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3.	Total 25 Marks for Experiments
Evaluation Exam	
Based on the subject and related lab of **Recommendation Systems and Theory**	

Lab Code	Lab Name	Credit
ADDOL8023	**Social Media Analytics Lab**	**1**

Prerequisite: Types of Graphs, Data Mining, Data Analytics	
Lab Objectives:	
1	To understand the fundamental concepts of social media networks.
2	To learn various social media analytics tools and evaluation matrices.
3	To collect and store social media data.
4	To analyze and visualize social media data
5	To design and develop social media analytics models.
6	To design and build a social media analytics application.
Lab Outcomes: The students will be able to	
1	Understand characteristics and types of social media networks.
2	Use social media analytics tools for business
3	Collect, monitor , store and track social media data
4	Analyze and visualize social media data from multiple platforms
5	Design and develop content and structure based social media analytics models.
6.	Design and implement social media analytics applications for business.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Study various - 1. Social Media platforms (Facebook, twitter, YouTube etc) 2. Social Media analytics tools (Facebook insights, google analytics net lytic etc) 3. Social Media Analytics techniques and engagement metrics (page level, post level, member level) 4. Applications of Social media analytics for business. e.g. Google Analytics https://marketingplatform.google.com/about/analytics/ https://netlytic.org/
2	Data Collection-Select the social media platforms of your choice (Twitter, Facebook, LinkedIn, YouTube, Web blogs etc), connect to and capture social media data for business (scraping, crawling, parsing).
3	Data Cleaning and Storage- Preprocess, filter and store social media data for business (Using Python, MongoDB, R, etc).
4	Exploratory Data Analysis and visualization of Social Media Data for business.

5	Develop Content (text, emoticons, image, audio, video) based social media analytics model for business. (e.g. Content Based Analysis: Topic , Issue ,Trend, sentiment/opinion analysis, audio, video, image analytics)
6	Develop Structure based social media analytics model for any business. (e.g. Structure Based Models -community detection, influence analysis)
7	Develop a dashboard and reporting tool based on real time social media data.
8	Design the creative content for promotion of your business on social media
	platform.
9	Analyze competitor activities using social media data.
10	Develop social media text analytics models for improving existing product/ service by analyzing customer 's reviews/comments.

Reference Books:	
1	Python Social Media Analytics: Analyze and visualize data from Twitter, YouTube, GitHub, and more Kindle Edition by Siddhartha Chatterjee , Michal Krystyanczuk
2	Learning Social Media Analytics with R,byRaghav Bali, Dipanjan Sarkar, Tushar Sharma.
3	Jennifer Golbeck, Analyzing the social web, Morgan Kaufmann, 2013
4	Matthew A. Russell. Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More, 2nd Edition, O'Reilly Media, 2013
5	Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011

Term Work:	
1	Term work should consist of 8(min) to 12(max) experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	Total 25 Marks for Experiments
Evaluation Exam	
Based on the subject and related lab of Social Media Analytics and Theory	

Course Code:	Course Title	Credit
ADP801	Major Project 2	6

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

Guidelines:

1. Internal guide has to keep track of the progress of the project and also has to maintainattendance report. This progress report can be used for awarding term work marks.

2. Project Report Format:

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai. Report should be submitted in hardcopy. Also, each group should submit softcopy of the report along with project documentation, implementation code, required utilities, software and user Manuals.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective
- Proposed System
  - Analysis/Framework/ Algorithm
  - Design details
  - Methodology (your approach to solve the problem) Proposed System
- Experimental Set up

- Details of Database or details about input to systems or selected data
- Performance Evaluation Parameters (for Validation)
- Software and Hardware Setup

- Results and Discussion
- Conclusion and Future Work
- References
- Appendix – List of Publications or certificates

Desirable:
Students should be encouraged -

- to participate in various project competition.
- to write minimum one technical paper & publish in good journal.
- to participate in national / international conference.

3. Term Work:

Distribution of marks for term work shall be done based on following:

a. Weekly Log Report
b. Completeness of the project and Project Work Contribution
c. Project Report (Black Book) (both side print)
d. Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

4. Oral & Practical:

Oral &Practical examination (Final Project Evaluation) of Project 2 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

Suggested quality evaluation parameters are as following:

a. Relevance to the specialization / industrial trends
b. Modern tools used
c. Innovation
d. Quality of work and completeness of the project
e. Validation of results
f. Impact and business value
g. Quality of written and oral presentation
h. Individual as well as teamwork