INDIAN INSTITUTE OF TECHNOLOGY PATNA

Continuing Education Programme
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Sl. No.	Subject Code	**SEMESTER I**	**L**	**T**	**P**	**C**
1	ECS 5101	Design and Analysis of Algorithms	3	0	2	4
2	ECS 5102	Foundations of Computer Systems	3	0	2	4
3	EMC 5103	Probability and Statistics	3	0	2	4
4	EHS 5104	Technical Writing and Soft Skill/Capstone Project	1	2	2	4
5		DE-1(Elective 1)	3	0	0	3
	TOTAL		**13**	**2**	**8**	**19**

**Capstone Project (Optional) online industry case study

Sl. No.	Subject Code	**SEMESTER II**	**L**	**T**	**P**	**C**
1	ECS 5201	Artificial Intelligence	3	0	2	4
2	EMC 5202	Numerical Linear Algebra and Optimization Techniques	3	0	2	4
3		DE-2(Elective 2)	3	0	0	3
4		DE-3(Elective 3)	3	0	0	3
5		IKS	2	0	0	2
	TOTAL		**14**	**0**	**4**	**16**

Sl. No.		**SEMESTER III**	**L**	**T**	**P**	**C**
1		DE-4(Elective 4)	3	0	0	3
2		DE-5(Elective 5)	3	0	0	3
3		Project I	0	0	34	17
	TOTAL		**6**	**0**	**34**	**23**

Sl. No.		**SEMESTER IV**	**L**	**T**	**P**	**C**
1		DE-6(Elective 6)	3	0	0	3
2		DE-7(Elective 7)	3	0	0	3
3		Project II	0	0	40	20
	TOTAL		**6**	**0**	**40**	**26**

Total credits = 84

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Electives for Executive M.Tech Big Data & Block Chain:

Sl. No.	Subject Code	Elective-I	L	T	P	C
1	EBB 6101	Web Development for Blockchain Applications	3	0	0	3
2	EBB 6102	Blockchain Components and Architecture	3	0	0	3
3	EBB 6103	Data Engineering	3	0	0	3

Sl. No.	Subject Code	Elective-II, III	L	T	P	C
1	EBB 6201	Database system and Design	3	0	0	3
2	EBB 6202	Deep Learning	3	0	0	3
3	EBB 6203	Data Virtualization and Dashboards	3	0	0	3
4	EBB 6204	Predictive Analytics	3	0	0	3

Sl. No.	Subject Code	Elective-IV, V	L	T	P	C
1	EBB 6301	Cryptocurrency and Cyber Security	3	0	0	3
2	EBB 6302	Big-Data Framework	3	0	0	3
3	EBB 6303	Modern Cryptography	3	0	0	3
4	EBB 6304	Blockchain Technologies: Platforms and Applications	3	0	0	3

Sl. No.	Subject Code	Elective- VI, VII	L	T	P	C
1	EBB 6401	Smart contracts and solidity programming	3	0	0	3
2	EBB 6402	Blockchain policy – Legal, social and economic impact	3	0	0	3
3	EBB 6403	Security and privacy for big data	3	0	0	3
4	EBB 6404	Data Mining and Knowledge Discovery	3	0	0	3

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Course number	**ECS 5101**
Course Credit	L-T-P-C: 3-0-2-4
Course Title	**Design and Analysis of Algorithms**
Learning Mode	Online
Learning Objectives	The objective of this course is to equip students with a solid understanding of data structures and algorithms, enabling them to design, analyze, and implement efficient algorithms to solve complex computational problems. The course covers fundamental topics such as data structures, complexity analysis, sorting and searching techniques, problem-solving strategies, graph algorithms, and advanced topics like string matching, FFT-DFT, and approximation algorithms. By the end of the course, students will have developed the skills to critically analyze algorithm efficiency and apply advanced algorithms in practical scenarios.
Course Description	This course will provide basic understanding of methods to solve problems on computers. It will also provide an overview to analyze those theoretically.
Course Outline	Data structures: linked list, stack, queue, tree, balanced tree, graph; Complexity analysis: Big O, omega, theta notation, solving recurrence relation, master theorem Sorting and searching: Quick sort, merge sort, heap sort; Sorting in linear time; Ordered statistics; Problem solving strategies: recursion, dynamic programming, branch and bound, backtracking, greedy, divide conquer, Graph algorithms: BFS, DFS, Shortest path, MST, Network flow; NP-completeness Advanced topics: string matching, FFT-DFT, basics of approximation and randomized algorithms. Lab Component: Implementation of above topics
Learning Outcome	By the end of this course, students will be able to: Use linked lists, stacks, queues, trees, balanced trees, and graphs. Analyze algorithm complexity and solve recurrence relations. Implement Quick sort, Merge sort, Heap sort, and linear time sorting methods. Apply recursion, dynamic programming, branch and bound, backtracking, greedy, and divide-and-conquer methods. Implement BFS, DFS, shortest path algorithms, MST, and network flow algorithms. Comprehend NP-completeness and its significance.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading:

- Mark Allen Weiss, "Data Structures and Algorithms in C++", Addison Wesley, 2003.
- Adam Drozdek, "Data Structures and Algorithms in C++", Brooks and Cole, 2001.
- Aho, Hopcroft and Ullmann, "Data structures and Algorithm", Addison Welsey, 1984.
- Introduction to Algorithms Book by Charles E. Leiserson, Clifford Stein, Ronald Rivest, and Thomas H. Cormen

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Course Number	**ECS 5102**
Course Credit	L-T-P-C: 3-0-2-4
Course Title	**Foundations of Computer Systems**
Learning Mode	Online
Learning Objective	The objective of the course is to provide a conceptual and theoretical understanding of computer architecture and operating systems.
Course Description	Foundations of computer systems is a review of two fundamental subjects of computer science viz., computer architecture and operating systems.
Course Outline	**Computer architecture:** Performance measures, Memory Location and Operations, Addressing Modes, Instruction Set, A Simple Machine, Instruction Mnemonics and Syntax, Machine Language Program, Assembly Language Program with examples. Processing Unit Design: Registers, Datapath, CPU instruction cycle, Instructions and Micro-operations in different bus architectures, Interrupt handling, Control Unit Design: Control signals, Hardwired Control unit design, Microprogram Control unit design. Pipelining and parallel processing, Pipeline performance measure, pipeline architecture, pipeline stall (due to instruction dependancy and data dependancy), Methods to reduce pipeline stall. RISC and CISC paradigms, I/O Transfer techniques, Memory organization: hierarchical memory systems, cache memories, virtual memory. **Operating systems:** Process states, PCB, Fork, exec system call, Threads, Process scheduling, Concurrent processes, Monitors, Process Synchronization, Producer Consumer Problem, Critical section, semaphore, Various process synchronization problems. Deadlock, Resource Allocation Graph, Deadlock prevention, Deadlock Avoidance: Banker's Algorithm and Safety Algorithm. Memory management techniques, Allocation techniques, Paging, Page Replacement Algorithms, Numericals. Lab Component: Implementation of above topics
Learning Outcome	This course will revisit two fundamental subjects of computer science viz., computer architecture and operating systems, thereby enabling the students to pursue more advanced problems in computer science based on these topics.
Assessment Method	Quiz / Assignment / ESE

Suggested readings:

1. A. Silberschatz, P. B. Galvin and G. Gagne, Operating System Concepts, 7th Ed, John Wiley and Sons, 2004.
2. M. Singhal and N. Shivratri, Advanced Concepts in Operating Systems, McGraw Hill, 1994.
3. David A Patterson and John L Hennessy, Computer Organisation and Design: The Hardware/Software Interface, Morgan Kaufmann, 1994. ISBN 1-55860-281-X.

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Course Number	**EMC 5103**
Course Credit (L-T-P-C)	L-T-P-C: 3-0-2-4
Course Title	**Probability and Statistics**
Learning Mode	Online
Learning Objective	To understand the basic concepts in Probability Theory and Statistics through practical examples.
Course Description	The course is divided into two parts: In first part, basic concepts of probability theory are introduced. In the second part, different problems in classical statistics are discussed.
Course Outline	Conditional probability, Bayes' rule, Total probability law, Independence of events. Random variables (discrete and continuous), probability mass functions, probability density functions, Expectation, variance, moments, cumulative distribution functions, Function of random variables, Multiple random variables, joint and marginal, conditioning and independence, Markov and Chebyshev inequalities, Different notions of convergence. Weak law of large number, Central limit theorem. Estimation: Properties, Unbiased Estimator, Minimum Variance Unbiased Estimator, Rao-Cramer Inequality and its attainment, Maximum Likelihood Estimator and its invariance property, Efficiency, Mean Square Error. Confidence Interval: Coverage Probability, Confidence level, Sample size determination. Testing of Hypotheses: Null and Alternative Hypotheses, Test Statistic, Error Probabilities, Power Function, Level of Significance, Neyman-Pearson Lemma.
Learning Outcome	Students will become familiar with principal concepts probability theory and statistics. This helps them to handle, mathematically, various practical problems arising in uncertain situations.
Assessment Method	Quiz / Assignment / ESE

Text Books:

1. Ross, S.M.(2008) Introduction to Probability Models, Ninth edition, Academic Press.
2. Statistical Inference (2007), G. Casella and R.L. Berger, Duxbury Advanced Series.

Reference Book:

1. An Introduction to Probability and Statistics, V.K. Rohatgi and A.K.Md. Ehsanes Saleh, John Wiley, 2nd Ed, 2009.

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Course Number	**ECS 5201**
Course Credit	L-T-P-C: 3-0-2-4
Course Title	**Artificial Intelligence**
Learning Mode	Online
Learning Objectives	● To understand the foundational concepts and motivations behinrtificial Intelligence and intelligent agents. ● To learn and apply uninformed and informed search strategies for problem-solving. ● To explore local search techniques and optimization methods beyond classical search. ● To implement adversarial search techniques and problem reduction strategies. ● To formulate and solve Constraint Satisfaction Problems (CSPs) using advanced techniques.
Course Description	This course aims to provide students with a comprehensive understanding of the fundamental principles and techniques of Artificial Intelligence (AI). It covers the basics of intelligent agents and their environments, various problem-solving methods through search strategies, and techniques beyond classical search. Students will learn about adversarial search, constraint satisfaction problems, knowledge representation, reasoning, planning, and various learning techniques. The course prepares students to design and implement AI solutions for complex real-world problems.
Course Outline	● Introduction and motivation Artificial Intelligence, intelligent agents, nature of environments ● Problem-solving by searching: Example problems, uninformed, informed search strategies ● Uninformed/ blind search techniques: Breadth-first search (BFS), Depth-first search (DFS), Uniform-cost search (UCS) ● Informed search: Heuristic function design and evaluation, A* search ● Beyond classical search: local search techniques and optimization, hill climbing, simulated annealing, beam search ● Adversarial search: Games, optimal decision in games, min-max, alpha-beta pruning, partially observable games ● Problem reduction techniques: And-OR (AO) and AO* ● Constraint Satisfaction Problem (CSP): definition and examples of CSPs, basic techniques: backtracking search, forward checking, arc consistency

	● Knowledge Representation, Reasoning, and Planning: Propositional logic, first-order logic, inference, planning ● Learning Techniques: meta-heuristic (genetic algorithm), Bayesian, decision tree, etc. ● Some advanced techniques of AI and its applications ● Lab component: Implementation of above architectures.
Learning Outcome	By the end of this course, students will be able to: ● Understand the foundational concepts and motivations behind Artificial Intelligence and intelligent agents. ● Apply uninformed and informed search strategies to solve example problems. ● Utilize local search techniques and optimization methods such as hill climbing, simulated annealing, and beam search. ● Implement adversarial search techniques including min-max, alpha-beta pruning, and strategies for partially observable games. Apply problem reduction techniques. ● Formulate and solve Constraint Satisfaction Problems (CSPs) using techniques like backtracking search, forward checking, and arc consistency. ● Represent knowledge using propositional and first-order logic, and perform inference and planning. ● Explore and apply various learning techniques such as genetic algorithms, Bayesian methods, and decision trees.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading

1. Russell, S. J., & Norvig, P. (2016). Artificial intelligence: A modern approach. Pearson.
2. Poole, D. L., & Mackworth, A. K. (2010). Artificial Intelligence: foundations of computational agents. Cambridge University Press.
3. Hastie, T., Tibshirani, R., Friedman, J. H., & Friedman, J. H. (2009). The elements of statistical learning: data mining, inference, and prediction (Vol. 2, pp. 1-758). New York: Springer.

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Course Number	**EMC 5202**
Course Credit	L-T-P-C: 3-0-2-4
Course Title	**Numerical Linear Algebra and Optimization Techniques**
Learning Mode	Online
Learning Objectives	The objective of the course is to train students about the different numerical techniques to solve linear equations, linear least square problems and find eigen values of matrices as well as check the stability of numerical methods. Moreover, students would be able to perform modeling of convex programming problems and employ various classical and numerical optimization techniques and algorithms to solve these problems
Course Description	Numerical Linear Algebra and Optimization Techniques, as a basic subject for postgraduate students, provides the knowledge of various numerical techniques to solve linear equations as well as check the stability of numerical methods. Moreover, this course would help the students to models convex optimization problems and learn different algorithms to solve such problems with its applications in various problems arising in economics, science and engineering.
Course Content	Review of matrix Algebra, Norms and condition numbers of Matrix, Systems of Equations, Gaussian Elimination, LU, PLU and Cholesky Factorization, Iterative Solvers: Jacobi, Gauss Seidel, SOR and their convergence, Gram-Schmidt orthogonalization QR Factorization and Least Squares, Eigenvalues, Power method, Reduction to Hessenberg or Tridiagonal form, Rayleigh quotient, inverse iteration, QR Algorithm without and with shifts, Singular Value Decomposition and Its applications Introduction to nonlinear programming, Convex Sets, Convex Functions and their properties. Unconstrained optimization of functions of several variables: Classical techniques. Numerical methods for unconstrained optimization: One Dimensional Search Methods, Golden Section Search and Fibonacci search, Basic descent methods, Conjugate direction, Newton's and Quasi-Newton methods Constrained optimization of functions of several variables, Lagrange Multiplier method, Karush-Kuhn-Tucker theory, Constraint Qualifications, Convex optimization Merit functions for constrained minimization, logarithmic barrier function for inequality constraints, A basic barrier-function algorithm Practice of algorithms using Software.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand different Matrix factorization method and employ them to solve linear equations and linear least square problems 2. To comprehend the basic computer arithmetic and the concepts of conditioning and stability of a numerical method. 3. Understand the terminology and basic concepts of various kinds of convex optimization problems and solve different solution methods to solve convex Programing problem.
Assessment Method	Quiz / Assignment /ESE

Text Books:

1. Lloyd N. Trefethen, David Bau III: Numerical Linear Algebra, 1st Edition, SIAM, Philadelphia (1997)
2. Edwin K. P. Chong, Stanislaw H. Zak: An Introduction to Optimization, 4th Edition, Wiley India (2017)
3. Gilbert Strang: Lecture Notes for Linear Algebra, Wellesley Cambridge Press, SIAM (2021)

Reference Books:

1. Stephan Boyd and Lieven. Vandenberghe: Convex Optimization, Cambridge University Press (2004)

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Course Number	**EBB 6101**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Web development for blockchain applications**
Learning Mode	Online
Learning Objectives	● Understand the basics of Blockchain Technology and its integration with Web Development. ● Gain hands-on experience in developing blockchain-based web applications using JavaScript and Python. ● Explore different server-side options and databases for building blockchain applications. ● Learn about web security, continuous integration, and deployment of blockchain applications on a production server.
Course Description	This course introduces the fundamentals of Blockchain Technology and its integration with web development, focusing on hands-on experience in building blockchain-based web applications using JavaScript and Python. Students will explore various server-side options, databases, web security, and learn continuous integration and deployment of blockchain applications on a production server.
Course Outline	**Module 1 : Introduction to Blockchain Web Development** ● Blockchain Technology and its integration with Web Development ● Technology stacks for blockchain-based web development ● HTML5 & CSS for blockchain-based web development ● Chrome DevTools for web development ● Functional programming paradigm for JavaScript inside a browser ● Python data types and basics ● Building client and server for blockchain applications ● Miner and wallet for blockchain applications ● Building a socket communication utility for blockchain applications ● Use of Low Code, No Code Tools in the development **Module 2 : JavaScript for Blockchain Web Development** ● JavaScript enabled blockchain applications ● Compiling new JavaScript to the old one with webpack ● Better CSS with webpack ● Code organization in a project ● Asynchronous JavaScript code for developing smart contracts ● APIs for blockchain solutions ● Building a simple blockchain application

Module 3: Server-side Development for Blockchain Applications

- Overview of server-side options for blockchain applications
- Node.js environment for blockchain and its ecosystem
- JSON REST API for blockchain applications
- Using Postman to debug APIs
- Managing server-side application state for blockchain applications
- Web3.js for blockchain web applications
- Databases and SQL (SQLite, PostgreSQL) for blockchain applications
- Data normalization for blockchain applications
- User authorization and authentication for blockchain applications.
- Allowing users to interact with blockchain applications.

Module 4 : Web Security and Development Organization for Blockchain Applications

- Web security basics for blockchain applications,Not trusting your clients for blockchain applications
- Why use HTTPS for blockchain applications,Integrating other software with the server for blockchain applications
- Developing frontend with React for blockchain applications
- Concept of single-page applications for blockchain applications,Managing client-side application state (Redux) for blockchain applications,Overview of other client JS frameworks for blockchain applications
- Development organization for blockchain applications
- Using Git for blockchain application development
- Concept of continuous integration for blockchain application development
- Configuring a production web server with Ubuntu for blockchain applications
- Concept of single-page applications for blockchain applications,Managing client-side application state (Redux) for blockchain applications,Overview of other client JS frameworks for blockchain applications
- Development organization for blockchain applications
- Using Git for blockchain application development
- Concept of continuous integration for blockchain application development
- Configuring a production web server with Ubuntu for blockchain applications

Learning Outcome	● Ability to build blockchain-based web applications using JavaScript and Python ● Understanding of server-side options and databases for building blockchain applications ● Proficiency in web security and deployment of blockchain applications on a production server ● Acquiring skills in using various web development tools and technologies for building blockchain applications.Understand the basics of application development frameworks and their importance in building complex software applications. ● Gain hands-on experience in using Spring, one of the most widely used Java-based application development frameworks. ● Develop proficiency in integrating Spring with relational databases, web services, and other enterprise systems. ● Choose and evaluate appropriate frameworks for specific application development needs.
Assessment Method	Quiz / Assignment / ESE

TEXTBOOKS:

- "Building Blockchain Projects: Building Decentralized Blockchain Applications with Ethereum and Solidity" by Narayan Prusty, published by Packt Publishing.
- "Blockchain Basics: A Non-Technical Introduction in 25 Steps" by Daniel Drescher, published by Apress.
- "Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained" by Imran Bashir, published by Packt Publishing.

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Course Number	**EBB 6102**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Blockchain components & architecture**
Learning Mode	Online
Learning Objectives	● To provide an in-depth understanding of the key concepts and components of blockchain technology. ● To explore the different types of blockchain architectures and design considerations, including security and consensus protocols. ● To examine the use of blockchain in various sectors, such as financial software and systems, government, and trade supply chains. ● To provide students with the knowledge and skills to develop secure cryptographic protocols on blockchain and analyze existing blockchain ecosystems.
Course Description	This course offers an in-depth understanding of blockchain architectures, and design considerations, including security and consensus protocols. Students will explore blockchain applications in various sectors and develop skills to create secure cryptographic protocols and analyze existing blockchain ecosystems.
Course Outline	**Module 1: Blockchain Fundamentals** ● Basic crypto primitives: hash, signature, hashchain to blockchain ● Basic consensus mechanisms ● Blockchain architecture and design considerations ● Requirements for consensus protocols. ● Scalability aspects of blockchain consensus protocols. **Module 2: Consensus Mechanism** ● Proof of Work (PoW) consensus mechanism ● Alternative consensus mechanisms: Proof of Stake (PoS), Delegated Proof of Stake (DPoS), Byzantine Fault Tolerance (BFT), and more ● Decomposing the consensus process ● Consensus protocols for permissioned blockchains. **Module 3: Permissioned Blockchains and Applications** ● Design goals for permissioned blockchains ● Introduction to Hyperledger Fabric ● Hyperledger Fabric components ● Chaincode design and implementation ● Beyond chaincode: Fabric SDK and front end, Hyperledger Composer tool ● Settlements, KYC, and capital markets on blockchain ● Blockchain in insurance.

	Module 4: Blockchain for Supply Chain and Government ● Use case: Blockchain in trade supply chain ● Provenance of goods and visibility on blockchain ● Trade supply chain finance on blockchain ● Invoice management and discounting on blockchain ● Digital identity and records on blockchain. ● Record keeping between government entities on blockchain ● Public distribution system and social welfare systems on blockchain **Module 5: Blockchain Cryptography, Privacy, and Security** ● Overview of blockchain cryptography and security ● Privacy on blockchain ● Recent works on scalability ● Secured multi-party computation on blockchain ● Blockchain for science: making better use of the data-mining network. **Case Studies**: Comparing ecosystems - Bitcoin, Hyperledger, Ethereum, and more.
Learning Outcome	● Students will be able to explain the core concepts and components of blockchain technology. ● Students will be able to design and implement basic blockchain architectures and understand the security and consensus mechanisms required for their development. ● Students will be able to analyze the use of blockchain in various sectors and identify opportunities for its implementation. ● Students will be able to develop secure cryptographic protocols on blockchain and compare and contrast different blockchain ecosystems, such as Bitcoin, Hyperledger, and Ethereum.
Assessment Method	Quiz / Assignment / ESE

TEXTBOOKS:

- "Blockchain Basics: A Non-Technical Introduction in 25 Steps" by Daniel Drescher, Apress.
- "Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World" by Don Tapscott and Alex Tapscott, Portfolio.
- "The Basics of Bitcoins and Blockchains" by Antony Lewis, O'Reilly Media.

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Course Number	**EBB 6103**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Data Engineering**
Learning Mode	Online
Learning Objectives	● To understand data engineering principles and practices, including data modeling, database design, and data warehousing. ● To develop skills in building efficient and scalable data pipelines for data processing and storage. ● To learn how to manage and optimize data systems for performance and reliability. ● To gain practical experience with data engineering tools and technologies, including SQL, ETL, and data warehousing.
Course Description	This course covers data engineering concepts and principles, focusing on designing and implementing efficient, scalable data pipelines for processing and storage.
Course Outline	**Module 1: Introduction to Data Engineering** ● Overview of Data Engineering ● Key Concepts in Data Modeling ● Relational Database Design Principles ● Data Warehousing Concepts **Module 2: Data Processing and Storage** ● Data Pipelines and ETL (Extract, Transform, Load) ● Distributed Systems and Parallel Computing ● Data Storage Technologies, including NoSQL databases ● Data Quality and Validation **Module 3: Managing and Optimizing Data Systems** ● Performance Tuning and Optimization ● Data Security and Privacy ● Scalability and Availability ● Disaster Recovery and Backup **Module 4: Data Engineering Tools and Technologies** ● SQL and Relational Database Management Systems ● Big Data Frameworks, including Hadoop and Spark ● Cloud-Based Data Warehousing, including Amazon Redshift and Google BigQuery ● Data Visualization and Reporting Tools

Learning Outcome	● Demonstrate an understanding of data engineering concepts and principles. ● Design and implement efficient and scalable data pipelines for data processing and storage. ● Manage and optimize data systems for performance and reliability. ● Apply data engineering tools and technologies to real-world data problems.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading

- Designing Data-Intensive Applications by Martin Kleppmann (O'Reilly Media)
- Data Warehousing in the Age of Big Data by Krish Krishnan (Morgan Kaufmann)
- The Data Warehouse Toolkit by Ralph Kimball and Margy Ross (Wiley)

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Course Number	**EBB 6201**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Database System and Design**
Learning Mode	Online
Learning Objectives	● To emphasize the underlying principles of Relational Database Management System. ● To model and design advanced data models to handle threat issues and countermeasures. ● To implement and maintain the structured, semi-structured and unstructured data in an efficient database system using emerging trends.
Course Description	This course provides a comprehensive understanding of database system fundamentals and design principles. Students will explore relational and NoSQL databases, practice database normalization, and work with database query languages like SQL. The course covers advanced topics like distributed databases, query optimization, and database security, combined with lab sessions to gain hands-on experience in designing and implementing databases.
Course Outline	**Module 1: Relational Model** ● Introduction to Database System Architecture ● EER Modeling ● Indexing ● Normalization ● Query processing and optimization ● Transaction Processing **Module 2: Parallel Databases** ● Architecture and Data Partitioning Strategies ● Interquery and Intraquery Parallelism ● Parallel Query Optimization **Module 3: Distributed Databases** ● Features of Distributed Databases ● Distributed Database Architecture ● Fragmentation and Replication ● Distributed Query Processing ● Distributed Transactions Processing ● **Module 4: Spatial and Mobile Databases** ● Introduction to Spatial Databases ● Types of Spatial Data ● Indexing in Spatial Databases ● Mobile Databases ● Transaction Model in MDS

Learning Outcome	• Design and implement database depending on the business requirements and considering various • design issues. Select and construct appropriate parallel and distributed database architecture and formulate the • cost of queries accordingly. • Understand the requirements of data and transaction management in mobile and spatial database • and differentiate those with RDBMS. Categorize and design the structured, semi-structured and unstructured databases. • Characterize the database threats and its countermeasures. • Review cloud, streaming and graph databases. • Comprehend, design and query the database management system.
Assessment Method	Quiz / Assignment / Lab Work / End Semester Exam (ESE)

TEXTBOOKS:

- S.K.Singh, "Database Systems: Concepts, Design Applications", 2nd edition,Pearson education, 2011.
- Joe Fawcett, Danny Ayers, Liam R. E. Quin: "Beginning XML", Wiley India Private Limited 5th Edition, 2012.
- Thomas M. Connolly and Carolyn Begg "Database Systems: A Practical Approach to Design, Implementation, and Management", 6th edition, Pearson India, 2015

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Course Number	**EBB 6202**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Deep Learning**
Learning Mode	Online
Learning Objectives	● Understand the fundamental concepts and architecture of neural networks. ● Learn various deep learning algorithms, including convolutional networks, recurrent networks, and autoencoders. ● Gain proficiency in training and optimizing deep neural networks for real-world applications. ● Explore deep learning applications in fields such as computer vision, natural language processing, and reinforcement learning. ● Learn to use deep learning frameworks like TensorFlow and PyTorch for hands-on implementation.
Course Description	This course provides an in-depth exploration of deep learning techniques, starting with the fundamentals of neural networks and progressing to advanced architectures such as convolutional and recurrent networks. Students will learn how to train deep neural networks using gradient-based optimization techniques, regularization methods, and hyperparameter tuning. The course emphasizes practical applications of deep learning in areas such as computer vision, natural language processing (NLP), and reinforcement learning. Students will gain hands-on experience with popular deep learning frameworks such as TensorFlow and PyTorch.
Course Outline	**Module 1: Introduction to Deep Learning** • Introduction to machine learning and deep learning concepts. • Overview of neural networks: perceptron, activation functions (ReLU, sigmoid, etc.). • Feedforward neural networks (FNN): forward propagation and backpropagation. • Loss functions: cross-entropy, mean squared error, etc. • Gradient descent optimization and its variants (SGD, Adam, RMSProp). **Module 2: Deep Neural Networks and Regularization** • Training deep neural networks: vanishing and exploding gradients. • Techniques to avoid overfitting: L2 and L1 regularization, dropout, batch normalization. • Hyperparameter tuning and optimization strategies: grid search, random search. • Model evaluation and cross-validation techniques. **Module 3: Convolutional Neural Networks (CNNs)** • Introduction to CNNs and their applications in computer vision. • CNN architecture: convolution layers, pooling layers, and fully connected layers. • Advanced CNN architectures: VGG, ResNet, and Inception networks. • Applications of CNNs in image classification, object detection, and segmentation.

	Module 4: Recurrent Neural Networks (RNNs) and Sequence Models • Introduction to RNNs: architecture and use in sequence data. • Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRUs) for handling long-range dependencies. • Applications of RNNs and LSTMs in natural language processing (NLP) tasks: language modeling, machine translation, and sentiment analysis. • Introduction to attention mechanisms and Transformer models. **Module 5: Autoencoders and Generative Models** • Autoencoders: structure and training, applications in data compression and denoising. • Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs). • Applications of generative models: image synthesis, text generation, and style transfer. **Module 6: Advanced Topics in Deep Learning** • Introduction to reinforcement learning: Q-learning, deep Q-networks (DQNs). • Deep learning for unsupervised and semi-supervised learning. • Transfer learning: fine-tuning pre-trained deep learning models. • Ethical considerations in deep learning: biases, fairness, and explainability. • Case studies of deep learning applications in healthcare, finance, and autonomous systems.
Learning Outcome	• Ability to design, train, and optimize deep neural networks for various applications. • Proficiency in using deep learning frameworks such as TensorFlow and PyTorch. • Understanding of advanced architectures like CNNs, RNNs, and GANs, and their real-world applications. • Practical skills in applying deep learning to domains such as computer vision, NLP, and reinforcement learning.
Assessment Method	Quiz / Assignment / End Semester Exam (ESE)

Suggested Reading

- "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press.
- "Neural Networks and Deep Learning: A Textbook" by Charu C. Aggarwal, Springer.
- "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron, O'Reilly Media.
- "The Elements of Statistical Learning: Data Mining, Inference, and Prediction" by Trevor Hastie, Robert Tibshirani, and Jerome Friedman, Springer.

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Course Number	**EBB 6203**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Data Virtualization and Dashboards**
Learning Mode	Online
Learning Objectives	1. To introduce students to the concept of data virtualization and its applications in the field of big data and blockchain. 2. To provide students with hands-on experience using popular data virtualization tools to create a unified view of data from multiple sources and running queries on the views in optimized manner. 3. To teach students how to design effective dashboards that provide meaningful insights into complex data sets and allows intelligent analytics o data. 4. To explore advanced topics in data virtualization and dashboards, such as real-time data integration, self-service analytics, and integration with big data platforms and blockchain.
Course Description	This course introduces data virtualization concepts and applications in big data and blockchain, offering hands-on experience with popular tools for unified data views and optimized querying. Students will learn to design effective dashboards for intelligent analytics and explore advanced topics, including real-time integration, self-service analytics, and integration with big data platforms and blockchain.
Course Outline	**Module 1: Introduction to Data Virtualization:** • Overview of data virtualization and its benefits, Data Silos, Data Partitioning, performance parameters of data virtualization. • Understanding data integration and how it differs from data virtualization, Centralized vs Peer-2-peer Data Integration, ETL, Mediation and Federated Databases. • Data Transformation, Master Data and Metadata Management in Data Virtualization. • Use cases for data virtualization. • Challenges and limitations of data virtualization. • Introduction to popular data virtualization tools and their architectures. **Module 2: Data Virtualization in Action:** • Building a virtual data layer with a popular data virtualization tool such as Denodo and TIBCO, Redhat JBOSS. • Connecting to various data sources (relational databases, big data systems, cloud applications, web applications, etc.). • Creating views and queries using the selected data virtualization tool, query optimization and caching in data virtualization. • Handling complex data transformations with the selected tool.

	• Managing metadata and security in a virtual environment. **Module 3: Data Visualization and Dashboards** • Introduction to data visualization and dashboard design. • Key principles of effective data visualization. • Overview of popular dashboard tools (e.g. Tableau, Power BI, QlikView), Creating reports in Tableau and Power BI. • Best practices for designing interactive dashboards. • Connecting virtual data sources to dashboards. **Module 4: Advanced Topics in Data Virtualization and Dashboards** • Using data virtualization to support self-service analytics, Experimenting self-service analytics in Denodo and Power BI. • Real-time data integration and processing with data virtualization. • Integrating data virtualization with big data platforms and blockchain. • Best practices for performance tuning and optimization in data virtualization. • Future trends in data virtualization and dashboard design.
Learning Outcome	• Students will be able to describe the benefits and challenges of data virtualization and how it differs from traditional data integration approaches. • Students will be able to create a virtual data layer using a popular data virtualization tool and connect to various data sources, including relational databases, big data systems, and cloud applications. • Students will be able to design effective dashboards using popular dashboard tools and connect virtual data sources to create interactive visualizations. • Students will be able to identify and apply advanced techniques in data virtualization and dashboard design, such as real-time data processing, self-service analytics, and integration with big data platforms and blockchain.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading

1. Data Virtualization for Business Intelligence Systems: Revolutionizing Data Integration for Data Warehouses (Rick van der Lans)
2. Data Visualization: A Practical Introduction (Kieran Healy)
3. The Big Book of Dashboards: Visualizing Your Data Using Real-World Business Scenarios (Steve Wexler, Jeffrey Shaffer, and Andy Cotgreave)
4. Building a Modern Data Center: Principles and Strategies of Design (Scott D. Lowe and David M. Davis)

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Course Number	**EBB 6204**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Predictive Analytics**
Learning Mode	Online
Learning Objectives	● Understand the key concepts of predictive analytics, including statistical models and machine learning algorithms. ● Gain proficiency in building predictive models using data-driven techniques. ● Learn to apply predictive analytics for solving business problems and decision-making. ● Explore tools and software used for predictive analytics, such as Python and R. ● Understand how to evaluate and interpret the results of predictive models.
Course Description	This course introduces students to the principles and techniques of predictive analytics. It focuses on building predictive models using statistical and machine learning methods. Students will learn how to apply predictive analytics to a variety of business and industry problems, using real-world datasets. The course also covers key evaluation metrics, model tuning, and the ethical implications of predictive models. Practical applications will be implemented using tools such as Python or R.
Course Outline	**Module 1: Introduction to Predictive Analytics** • Definition and importance of predictive analytics. • The role of data in predictive analytics: types of data (structured vs. unstructured). • Introduction to the predictive modeling process. • Understanding the difference between descriptive, predictive, and prescriptive analytics. • Applications of predictive analytics in business: customer churn, credit scoring, fraud detection, etc. **Module 2: Data Preparation for Predictive Modeling** • Data collection, cleaning, and preprocessing. • Handling missing data, outliers, and imbalanced datasets. • Feature engineering: creating meaningful features from raw data. • Data partitioning: training, testing, and validation datasets. • Data transformation techniques: normalization and standardization. **Module 3: Predictive Modeling Techniques** • **Regression Analysis:** o Linear regression, multiple regression, and polynomial regression. o Assumptions of regression models and diagnostics. • **Classification Techniques:** o Logistic regression, decision trees, and random forests. o Support Vector Machines (SVM) and k-Nearest Neighbors (k-NN). o Gradient boosting and ensemble methods (XGBoost, AdaBoost). • **Time Series Forecasting:** o ARIMA, exponential smoothing, and seasonal decomposition.

	o Trends, seasonality, and forecasting future values. **Module 4: Machine Learning in Predictive Analytics** • Introduction to supervised learning: classification and regression. • Key machine learning algorithms for predictive analytics: o Decision Trees, Random Forests, and Gradient Boosting Machines. o Support Vector Machines (SVM) and Neural Networks. • Model selection and hyperparameter tuning using cross-validation. • Introduction to unsupervised learning for pattern recognition (clustering, association). **Module 5: Model Evaluation and Optimization** • Performance metrics for regression: R-squared, Mean Absolute Error (MAE), Mean Squared Error (MSE). • Performance metrics for classification: Confusion Matrix, Precision, Recall, F1-Score, AUC-ROC curve. • Overfitting and underfitting: strategies to prevent overfitting (regularization, cross-validation). • Model tuning and optimization techniques: Grid Search, Random Search, and Hyperparameter Tuning. • Interpreting the results and communicating insights effectively. **Module 6: Advanced Topics in Predictive Analytics** • Introduction to deep learning techniques in predictive analytics. • Using predictive analytics for real-time data and streaming analytics. • Ethical considerations in predictive analytics: fairness, transparency, and accountability. • Case studies and industry applications of predictive analytics: healthcare, finance, marketing, etc. • Practical implementation using Python or R with libraries like scikit-learn, TensorFlow, and statsmodels.
Learning Outcome	• Comprehensive understanding of big data frameworks like Hadoop and Spark. • Ability to design and implement scalable data pipelines for batch and real-time processing. • Proficiency in managing and optimizing distributed data storage and processing systems. • Practical skills in working with various components of the Hadoop ecosystem and Spark framework. • Knowledge of best practices for big data security, performance tuning, and scalability.
Assessment Method	Quiz / Assignment / End Semester Exam (ESE)
TEXTBOOKS:	

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Course Number	**EBB 6301**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Cryptocurrency and Cyber Security**
Learning Mode	Online
Learning Objectives	● To understand the fundamentals of network and symmetric ciphers. ● To apply asymmetric ciphers and data integrity algorithms. ● To explore the basics of cryptocurrencies and use Ethereum programming
Course Description	This course provides a foundational understanding of cybersecurity and cryptography, with a focus on their applications in blockchain and cryptocurrency systems. Students will explore key encryption techniques, hash functions, and digital signatures, while also addressing privacy issues and security challenges in blockchain technology. The course covers modern cybersecurity infrastructures, such as blockchain-based identity management and DDoS protection, and examines security concerns in applications like IoT and payment systems.
Course Outline	**Module 1: Introduction to Cybersecurity and Cryptography** ● Need for cybersecurity,Concept of cyberspace, Cyber-crimes and cyber-attacks ● Fundamental security principles,Key security triad,Key components of cybersecurity network architecture,Basic security management and policies ● Cryptography,Private key cryptography,Classical encryption techniques,Substitution techniques Transposition techniques,Rotor machines,Steganography ● Data Encryption Standard,Advanced Encryption Standard, Multiple Encryption and Triple DES **Module 2: Asymmetric Cryptography and Hash Functions** ● Public-key cryptography,RSA algorithm,Diffie-Hellman key exchange,Elgamal cryptographic system ● Elliptic curve arithmetic,Elliptic curve cryptography,MD5 message digest algorithm ● Secure hash algorithm (SHA),Digital signatures ● Authentication protocols, Digital signature standards (DSS) **Module 3: Blockchain Security and Privacy Issues** ● Transaction security,Client security and privacy,Pseudo-anonymity vs anonymity ● Zcash and 2k-SNARKS for anonymity preservation ● Network layer attacks ● Security and privacy issues with scalability solutions,Balance privacy ● Wormhole attack

	Module 4: Cybersecurity Infrastructure using Blockchain ● Blockchain-based PKI ● 2-Factor authentication using blockchain ● Blockchain-based DNS ● Identity management ● Blockchain-based DDoS protection **Module 5: Security Aspects of Blockchain Applications** ● Blockchain for cybersecurity and privacy in IoT ● loT ● Payment system applications
Learning Outcome	● Recall the network security fundamentals. ● Employ various symmetric ciphers. ● Apply asymmetric ciphers and data integrity algorithms. ● Explore the basics of cryptocurrencies. ● Use Ethereum programming
Assessment Method	Quiz / Assignment / End Semester Exam (ESE)

TEXT BOOKS:

1. William Stallings, "Cryptography and Network security Principles and Practices", Pearson/PHI,2017.
2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", Princeton University Press, July, 2016.

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Course Number	**EBB 6302**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Big Data Framework**
Learning Mode	Online
Learning Objectives	● To provide a comprehensive understanding of Big Data and its ecosystem. ● To familiarize students with the design and implementation of Big Data frameworks and tools. ● To introduce techniques for distributed data processing, storage, and analysis.
Course Description	This course covers the foundational aspects of big data frameworks, including Hadoop, Spark, and other distributed computing frameworks used for large-scale data processing. Students will learn how to handle structured and unstructured data, design efficient data pipelines, and implement scalable solutions for real-time and batch data processing. The course also addresses key challenges in big data management, performance optimization, and data storage in distributed environments.
Course Outline	**Module 1: Introduction to Big Data** ● Overview of Big Data ● Big Data challenges and opportunities ● Big Data ecosystem and architecture ● Data storage and management techniques ● Introduction to Hadoop and MapReduce **Module 2: Big Data Processing Frameworks** ● Hadoop and its components: HDFS, MapReduce, YARN ● Apache Spark: RDD, DataFrames, and Datasets ● Apache Flink and Stream Processing ● Apache HBase and NoSQL databases ● Apache Cassandra: Data Model, Distribution, and Architecture **Module 3: Data Storage and Processing Techniques** ● Understanding the principles of cloud-native development ● Building and deploying cloud-native Java applications using popular frameworks such as Spring Boot and Quarkus **Experiments**: 1. Install and configure Hadoop, and develop a simple MapReduce program for word count analysis. 2. Set up Apache Spark, create Resilient Distributed Datasets (RDDs), and write a Spark application for data processing tasks. 3. Utilize Spark SQL and DataFrames to connect to databases, manipulate data, and run SQL queries. 4. Explore Spark MLlib, implement a basic machine learning algorithm, and evaluate its performance on a dataset.

	5. Integrate Spark with visualization libraries to create insightful data visualizations. 6. Set up a cloud-based Hadoop or Spark environment, and deploy a sample big data application. 7. Monitor and manage the deployed application using the cloud provider's management console. 8. Gain proficiency in various aspects of big data processing, analysis, and visualization using Hadoop and Spark frameworks.
Learning Outcome	• Understand the concepts and principles of Big Data and its ecosystem. • Design and implement Big Data frameworks using distributed processing systems. • Apply various data storage and processing techniques for handling large-scale datasets.
Assessment Method	Quiz / Assignment / End Semester Exam (ESE)

TEXTBOOKS:

- Mike Frampton, "Mastering Apache Spark", Packt Publishing, 2015.
- Tom White, "Hadoop: The Definitive Guide", O'Reilly, 4th Edition, 2015.
- Nick Pentreath, Machine Learning with Spark, Packt Publishing, 2015.
- Mohammed Guller, Big Data Analytics with Spark, Apress, 2015
- Donald Miner, Adam Shook, "Map Reduce Design Pattern", O'Reilly, 2012

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Course Number	**EBB 6303**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Modern Cryptography**
Learning Mode	Online
Learning Objectives	● To understand the fundamentals of modern cryptography, including symmetric and asymmetric ciphers, hash functions, and digital signatures. ● To explore the mathematics behind modern cryptography, including modular arithmetic, prime numbers, and finite fields. ● To gain knowledge of widely-used cryptographic algorithms, including RSA, AES, and SHA. ● To learn about the practical application of cryptography in information security, authentication, and data protection.
Course Description	This course introduces students to the core principles of modern cryptography, covering both theoretical foundations and practical applications. Students will learn about symmetric encryption techniques like AES, as well as public-key cryptosystems such as RSA and elliptic curve cryptography (ECC). The course also covers cryptographic hash functions, digital signatures, and protocols for ensuring secure communication. Advanced topics like zero-knowledge proofs, homomorphic encryption, and quantum-resistant cryptography will also be discussed. Practical applications of cryptographic techniques in areas like blockchain, cybersecurity, and data privacy will be emphasized.
Course Outline	**Module 1: Fundamentals of Cryptography** ● Modular arithmetic, polynomial arithmetic, and finite fields ● Symmetric ciphers and their types ● Asymmetric ciphers and their types ● Hash functions and message authentication codes **Module 2: Cryptographic Algorithms** ● Advanced Encryption Standard (AES) and Data Encryption Standard (DES) ● RSA algorithm and Diffie-Hellman key exchange ● Elliptic curve cryptography ● Digital signatures and authentication mechanisms **Module 3: Cryptographic Applications and Tools** ● Cryptographic tools and libraries ● Authentication and key establishment ● Cryptographic protocols and standards ● Cryptography and information security
Learning Outcome	● Understand the fundamental principles of modern cryptography and its mathematical foundations. ● Evaluate the security of cryptographic algorithms and design secure systems based on modern cryptographic techniques.

	• Design and implement secure data encryption, authentication, and signature mechanisms using cryptographic tools and algorithms. • Apply cryptography in various fields, including computer science, finance, and government, to achieve secure and confidential communication.
Assessment Method	Quiz / Assignment / End Semester Exam (ESE)

TEXTBOOKS

- "Applied Cryptography: Protocols, Algorithms, and Source Code in C" by Bruce Schneier, published by Wiley.
- "Cryptography and Network Security: Principles and Practice" by William Stallings, published by Prentice Hall.
- "Introduction to Modern Cryptography" by Jonathan Katz and Yehuda Lindell, published by CRC Press.
- "Serious Cryptography: A Practical Introduction to Modern Encryption" by Jean-Philippe Aumasson, published by No Starch Press.

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Course Number	**EBB 6304**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Blockchain Technologies: Platforms and Applications**
Learning Mode	Online
Learning Objectives	● Articulate blockchain platforms that show promise in solving complex business problems ● Examine the life cycle of a chain code and its components ● Implement various blockchain-based enterprise applications
Course Description	This course introduces students to the principles and techniques of predictive analytics. It focuses on building predictive models using statistical and machine learning methods. Students will learn how to apply predictive analytics to a variety of business and industry problems, using real-world datasets. The course also covers key evaluation metrics, model tuning, and the ethical implications of predictive models. Practical applications will be implemented using tools such as Python or R.
Course Outline	**Module 1 - INTRODUCTION TO BLOCKCHAIN TECHNOLOGIES** ● Introduction to Blockchain Technologies ● Overview of Blockchain Platforms: Ethereum, Hyperledger Project, IBM Blockchain, Multichain, Hydrachain, Ripple, R3 Corda, BigChainDB, IPFS **Module 2 - ETHEREUM SMART CONTRACTS** ● Introduction to Smart Contracts ● Solidity Programming Language ● Contract Creation and Deployment ● Web3js and RPC Protocols ● Miners, Transactions, and Blocks in Ethereum ● Front-End Development with React and Web3 **Module 3 - HYPERLEDGER FABRIC** ● Introduction to Hyperledger Fabric ● Fabric Model ● Identity Management in Fabric: Membership Service Provider (MSP) ● Policies in Fabric ● Ledgers in Fabric: World State and Transaction Log ● Chaincode in Fabric: Writing and Deploying Smart Contracts ● Endorsement Peers and Endorsement Policies in Fabric **Module 4 - ADVANCED TOPICS IN BLOCKCHAIN TECHNOLOGIES** ● Ordering Nodes in Hyperledger Fabric: Solo Ordering Service, Kafka ● Committing Peers and Anchor Peers in Hyperledger Fabric ● Private Data Sharing in Hyperledger Fabric: Sharing Private Data, Private Data Sharing Patterns ● Key-level Transaction Access Control and Endorsement in Hyperledger Fabric ● Setting up a Production Network on Hyperledger Fabric

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Learning Outcome	• Comprehensive understanding of big data frameworks like Hadoop and Spark. • Ability to design and implement scalable data pipelines for batch and real-time processing. • Proficiency in managing and optimizing distributed data storage and processing systems. • Practical skills in working with various components of the Hadoop ecosystem and Spark framework. • Knowledge of best practices for big data security, performance tuning, and scalability.
Assessment Method	Quiz / Assignment / End Semester Exam (ESE)

TEXTBOOKS:

- Tom Serres, Bill Wagner and Bettina Warburg, Basics of Blockchain (1 ed.), missing, 2019. ISBN 9781089919441.
- a) Gaur and Nitin, Hands-On Blockchain with Hyperledger: Building decentralized applications with Hyperledger Fabric an (1 ed.), Packt Publishing Ltd, 2018. ISBN 978-17889945

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Course Number	**EBB 6401**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Smart Contracts and Solidity Programming**
Learning Mode	Online
Learning Objectives	• To provide an introduction to the concept of smart contracts and their applications. • To familiarize students with the Solidity programming language and its constructs. • To enable students to design, implement, and deploy smart contracts on the Ethereum blockchain. • To teach students best practices for secure smart contract development and auditing.
Course Description	This course introduces students to the development of smart contracts using the Solidity programming language on the Ethereum blockchain. Students will learn the architecture of smart contracts, how to write and deploy them, and best practices for secure contract development. The course emphasizes hands-on experience with real-world applications in decentralized finance (DeFi), digital identity, and other blockchain-based systems.
Course Outline	**Module 1: Introduction to Smart Contracts and Solidity** • Definition and brief history of smart contracts,Applications of smart contracts • Introduction to the Ethereum blockchain • Solidity programming language and its syntax • Structure of a smart contract,Global variables in Solidity **Module 2: Ethereum Development** • Life cycle of a Solidity contract,Interfaces and inheritance in Solidity,External function calls • Fallback functions,Payable functions and transactions,Revert, assert, and require statements • Decentralized Autonomous Organizations (DAOs) • Introduction to MakerDAO **Module 3: Advanced Solidity Development** • Token-based membership,Share-based membership,Automated immutable systems • Pure functions and view functions,Ethereum Virtual Machine (EVM) • Bytecode interpretation • Ethereum mining reward scheme,Gas pricing **Module 4: Security and Auditing of Smart Contracts** • Security issues in smart contracts,Common attacks on smart contracts,Error handling in smart contracts • Best practices for secure smart contract development,Modifiers • Mutex pattern and balance limit pattern,Smart contract security tools, including Smart Inspect, GasTap, Smart Check, and Solgraph • Advanced research topics in smart contracts

Learning Outcome	• Students will be able to understand the purpose and potential of smart contracts in various industries. • Students will be able to write smart contracts in Solidity and deploy them on the Ethereum blockchain. • Students will be able to design and implement secure smart contracts, and avoid common security issues. • Students will be able to apply best practices for auditing and testing smart contracts.
Assessment Method	Quiz / Assignment / End Semester Exam (ESE)

Textbook:

1. "Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained" by Imran Bashir. Packt Publishing, 2018.
2. "Building Ethereum Dapps: Decentralized Applications on the Ethereum Blockchain" by Roberto Infante. Apress, 2018.
3. "Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Blockchain" by Ritesh Modi. Packt Publishing, 2018.

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Course Number	**EBB 6402**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Blockchain policy – Legal, social and economic impact**
Learning Mode	Online
Learning Objectives	● Understand the importance and impact of blockchain policies, regulations, and guidelines. ● Analyze the different stakeholders and communities affected by blockchain policies and their implications. ● Develop skills for drafting and implementing blockchain policies to ensure sustainable infrastructure investment and international trade. ● Evaluate the potential unintended consequences of blockchain and apply effective strategies for mitigating them.
Course Description	This course explores the regulatory, legal, and socio-economic implications of blockchain technology. Students will gain an understanding of global blockchain regulations, policy frameworks, and their impact on industries such as finance, supply chain, and healthcare. Topics include data privacy laws, cryptocurrency regulations, smart contract legality, and the broader societal changes driven by blockchain adoption.
Course Outline	**Module 1:Blockchain Policy and Guidelines:** ● Introduction to blockchain policies and their importance,Guidelines for blockchain applications and infrastructures,International laws and regulations related to blockchain ● Dialogue on distributed ledger technology (DLT),Policies for preventing money laundering and terrorism financing,FATF standards on virtual assets ● Stable coins and their policy implications,Issues related to trust and framework,Challenges and business impact of blockchain ● Resources for blockchain policies,Smart securities and derivatives **Module 2: Impact of Blockchain on Different Stakeholders:** ● Tokenization and securities for physical assets,Impact of blockchain on different stakeholders,Shareholder engagement and investor privacy ● Blockchain industry bodies around the world,Corporate governance on the chain,Impact on specific communities ● Problem of equality and blockchain ● Role of blockchain in the ecosystem for persons with disabilities,Impact of blockchain on women,Tax administration to transparency,Tax treatment of digital financial assets **Module 3: Enabling Sustainable Infrastructure Investment:** ● Digital financial marketplaces and track and trace,Provenance to countering fraud ● Agricultural supply chains and policy makers,Material supply chains ● Facilitating international trade,Trade finance to customs ● How government can support blockchain innovation,Blockchain adoption

	Module 4: Unintended Consequences and Technical Assistance: ● Blockchain and the environment,Steering blockchain through the energy transition ● Reducing the cost of remittances with blockchain ● Potential unintended consequences of blockchain ● Addressing criminal activities, inequality, privacy, security, and data protection,Intellectual property regulations
Learning Outcome	1. Develop a comprehensive understanding of blockchain policies, regulations, and guidelines. 2. Assess the impact of blockchain policies on different stakeholders and communities. 3. Draft and implement effective blockchain policies to enable sustainable infrastructure investment and international trade. 4. Analyze and mitigate the potential unintended consequences of blockchain for successful policy implementation.
Assessment Method	Quiz / Assignment / ESE

TEXTBOOKS:

1. "Blockchain and the Law: The Rule of Code" by Primavera De Filippi and Aaron Wright, published by Harvard University Press.
2. "The Age of Cryptocurrency: How Bitcoin and Digital Money are Challenging the Global Economic Order" by Paul Vigna and Michael Casey (St. Martin's Press, 2015)
3. "Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World" by Don Tapscott and Alex Tapscott (Portfolio, 2016).

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Course Number	**EBB 6403**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Security and Privacy for Big Data**
Learning Mode	Online
Learning Objectives	● Understand the basic concepts of Cryptography. ● Learn methods and tools for securing big data and how to apply them in practice. ● Understand differential privacy and its impact on big data. ● Be familiar with the laws and regulations regarding data protection in big data environments.
Course Description	This course covers the security challenges and privacy concerns associated with managing large-scale data in distributed systems. Students will learn cryptographic techniques, data anonymization methods, and access control mechanisms to secure big data environments. The course also explores privacy-preserving techniques such as differential privacy and examines data protection laws relevant to big data systems.
Course Outline	**Module 1: Cryptography for Big Data Security:** ● Introduction to cryptography and its relevance to big data,Symmetric and asymmetric encryption techniques ● Hash functions and message authentication codes (MACs) ● Public Key Infrastructure (PKI) and digital certificates ● Cryptographic protocols for secure communication in big data,Cryptographic tools and libraries for big data security **Module 2: Security and Privacy in Big Data:** ● Threat modeling and risk assessment for big data,Access control and authentication mechanisms for big data systems ● Data anonymization and privacy-preserving techniques for big data ● Network security and data protection in distributed big data systems ● Intrusion detection and prevention in big data environments,Best practices for securing big data and compliance with data protection laws **Module 3: Big Data Modeling for Security Analysis:** ● Data modeling and schema design for security analysis in big data,Machine learning and data mining techniques for security analysis in big data ● Visualization and analytics tools for security analysis in big data,Data fusion and correlation for security intelligence in big data ● Case studies of security analysis in big data environments ● Big data security testing and evaluation methodologies
Learning Outcome	● Understand the basic concepts of Cryptography. ● Develop skills and knowledge to apply different methods and tools to secure big data. ● Be able to analyze the impact of differential privacy and malware on big data.

	• Understand the data protection laws and regulations for big data and apply them in practice.
Assessment Method	Quiz / Assignment / ESE

Textbooks:

1. Big Data , Storage sharing and security , Fei Hu, CRC press
2. Privacy & Big data , by Mary E. Ludloff, Terence Craig. Released September 2011. Publisher(s): O'Reilly Media, Inc.

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Course Number	**EBB 6404**
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Data Mining and Knowledge Discovery**
Learning Mode	Online
Learning Objectives	● Understand the core principles and techniques of data mining and knowledge discovery. ● Learn to preprocess and transform large datasets to make them suitable for data mining. ● Apply data mining algorithms for classification, clustering, and association rule mining. ● Gain the ability to identify anomalies and patterns in large datasets. ● Explore the use of data mining in real-world applications and industries such as finance, healthcare, and retail.
Course Description	This course introduces the principles and methodologies of data mining and knowledge discovery in large datasets. It covers a range of techniques such as clustering, classification, association rule mining, and anomaly detection. The course emphasizes both theoretical understanding and practical implementation of data mining techniques. Students will learn how to extract valuable insights and patterns from data, with a focus on real-world applications such as fraud detection, market basket analysis, and business intelligence.
Course Outline	**Module 1: Introduction to Data Mining** • Overview of data mining and its importance in knowledge discovery. • Data mining vs. data analytics and business intelligence. • Key challenges and issues in data mining: data quality, privacy, and interpretability. • Applications of data mining in various industries: finance, healthcare, and e-commerce. • Introduction to data mining processes: CRISP-DM (Cross-Industry Standard Process for Data Mining). **Module 2: Data Preprocessing and Transformation** • Data cleaning techniques: handling missing data, noise, and outliers. • Data transformation: normalization, standardization, and discretization. • Feature selection and dimensionality reduction: PCA (Principal Component Analysis), LDA (Linear Discriminant Analysis). • Data integration and transformation in big data environments. • Handling imbalanced data in mining tasks: oversampling and undersampling techniques. **Module 3: Classification and Prediction** • Introduction to classification techniques: decision trees, k-Nearest Neighbors (k-NN), Naïve Bayes, and Support Vector Machines (SVM). • Performance evaluation: confusion matrix, precision, recall, F1-score, and AUC-ROC curves.

	• Overfitting and underfitting: strategies to handle them using cross-validation and pruning. • Ensemble methods: Bagging, Random Forests, and Boosting (e.g., AdaBoost, XGBoost). • Practical implementation using Python or R. **Module 4: Clustering and Anomaly Detection** • Clustering techniques: k-means, hierarchical clustering, DBSCAN (Density-Based Spatial Clustering of Applications with Noise). • Evaluating clustering performance: Silhouette score, Dunn index. • Identifying anomalies: distance-based, density-based, and clustering-based approaches. • Use of anomaly detection in fraud detection, cybersecurity, and network intrusion detection. • Practical application of clustering and anomaly detection techniques on large datasets. **Module 5: Association Rule Mining and Pattern Discovery** • Introduction to association rules: Apriori and FP-Growth algorithms. • Support, confidence, and lift in association rule mining. • Market basket analysis: discovering frequent itemsets and patterns. • Sequential pattern mining: algorithms and use cases. • Real-world applications in recommendation systems and retail analytics. **Module 6: Advanced Topics and Applications in Data Mining** • Temporal and spatial data mining. • Text mining and web mining: sentiment analysis, social media analytics. • Data mining with graph databases: community detection and network analysis. • Ethical considerations in data mining: privacy, security, and data ownership. • Case studies of data mining applications in industries such as healthcare, finance, and e-commerce.
Learning Outcome	• Ability to preprocess and transform raw data into suitable formats for mining. • Proficiency in applying various data mining algorithms for classification, clustering, and pattern discovery. • Understanding of anomaly detection techniques and their applications in fraud detection and cybersecurity. • Ability to evaluate and interpret the results of data mining models. • Practical skills in using data mining tools and libraries in Python/R for real-world applications.
Assessment Method	Quiz / Assignment / End Semester Exam (ESE)

TEXTBOOKS:

- **"Data Mining: Concepts and Techniques"** by Jiawei Han, Micheline Kamber, and Jian Pei, Morgan Kaufmann.
- **"Introduction to Data Mining"** by Pang-Ning Tan, Michael Steinbach, and Vipin Kumar, Pearson.

- **"Pattern Recognition and Machine Learning"** by Christopher Bishop, Springer.
- **"The Elements of Statistical Learning: Data Mining, Inference, and Prediction"** by Trevor Hastie, Robert Tibshirani, and Jerome Friedman, Springer.