Electives for Executive M.Tech Cloud Computing

Sl. No.	Subject Code	Elective-I	L	T	P	C
1	ECC 6101	Application development framework	3	0	0	3
2	ECC 6102	Python for cloud computing	3	0	0	3
3	ECC 6103	Advanced Cloud Computing	3	0	0	3

Sl. No.	Subject Code	Elective-II	L	T	P	C
1	ECC 6201	Cloud computing Architecture	3	0	0	3
2	ECC 6202	Cloud Security	3	0	0	3
3	ECC 6203	Advanced Edge Computing	3	0	0	3

Sl. No.	Subject Code	Elective-III	L	T	P	C
1	ECC 6301	Cloud strategy planning & Management	3	0	0	3
2	ECC 6302	Data virtualization and dashboard	3	0	0	3
3	ECC 6303	Distributed Systems	3	0	0	3

Sl. No.	Subject Code	Elective-III	L	T	P	C
1	ECC 6401	Meta Learning	3	0	0	3
2	ECC 6402	Service-oriented Architecture and Web security	3	0	0	3
3	ECC 6403	Reinforcement Learning	3	0	0	3

Course Number	ECC 6101
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Application Development Frameworks**
Learning Mode	Online
Learning Objectives	● Ability to build Java-based applications using the Spring framework and integrate them with relational databases and other enterprise systems. ● Understanding of key concepts such as aspect-oriented programming, dependency injection, and object-relational mapping. ● Familiarity with common Java development tools and techniques, including Spring MVC and RESTful web services. ● Ability to evaluate and select appropriate application development frameworks for specific use cases.
Course Description	This course teaches students to build Java-based applications using the Spring framework, integrating with relational databases and enterprise systems. It covers key concepts like aspect-oriented programming, dependency injection, and object-relational mapping, along with common Java development tools and techniques, including Spring MVC and RESTful web services.

Course Outline	**MODULE 1: Introduction to Application Development Frameworks** ● Overview of application development frameworks ● Advantages and disadvantages of using frameworks ● Introduction to the Spring framework ● Configuration and setup of Spring-based applications ● Bean life cycle and dependency injection ● Introduction to aspect-oriented programming **MODULE 2: Database Integration with Spring** ● Data access with Spring and JDBC ● Simplifying JDBC-based data access ● Using object-relational mapping (ORM) with Spring ● Introduction to Hibernate in a Spring environment ● Driving database transactions in a Spring environment **MODULE 3: Web Development with Spring** ● Introduction to web application architecture ● Overview of Spring MVC ● Restful web services with Spring MVC ● Securing web applications with Spring Security ● Rendering multiple content types with Spring **MODULE 4: Integration with Enterprise Systems** ● Introduction to enterprise information connectivity ● Serialization and remoting with Spring ● Introduction to messaging and transactions ● Working with JMS and transactional JMS ● Distributed transaction management
Learning Outcome	By the end of this course, students will be able to: ● 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:

1. Rod Johnson et al., "Professional Java Development with the Spring Framework," Wiley Pub, 2005.
2. Mark Fisher, "Spring Integration in Action," Manning Publications, 2011.
3. Craig Walls and Ryan Breidenbach, "Spring in Action," Manning Publications, 2007.
4. Paul Fisher and Solomon Duskis, "Spring Persistence with Hibernate," Apress, 2009.

Course Number	ECC 6102
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Python for Cloud Computing**
Learning Mode	Online
Learning Objectives	● To understand the fundamental concepts and components of Python Language. ● To understand how the loops, functions, modules and libraries are handled in Python Language. ● To understand how Object-Oriented Programming adopted in Python. ● To understand the debugging and testing (unit) techniques along with regular expressions. ● To understand how to develop web applications using Python. ● To understand how to automate tasks using Python. ● To understand how to use Python in automating tasks in Cloud Environment (AWS / GCP).
Course Description	This course covers fundamental Python concepts, including loops, functions, modules, libraries, and object-oriented programming. Students will learn debugging, unit testing, regular expressions, web development, task automation, and using Python for cloud automation in AWS and GCP.

Course Outline	**Module 1: Introduction to Python** History & need of Python, Application of Python, Installing Python, Program structure, Interactive Shell, Executable or script files, User Interface or IDE. **Module 2: Python Loops, Functions, Modules and Libraries** Conditional Statements, The Range Function, Built-In Function, Structure of Python Functions (e.g. - map, zip, reduce etc.), User Defined Functions **Module 3: Python Data Structure and OOP** Class and objects, OOPS Concept, Error handling, Python Debugger **Module 4: Cloud application development using Python** Develop a basic application using Django & Flask Framework, Deploy the developed application in the Cloud, connect to the Database, Building API in Python
Learning Outcome	● By the end of this course, students will be able to: ● Code in Python for making decisions and construct loops. ● Utilize in-built and user-defined functions in Python. ● Make use of libraries in Python. ● Design, plan and develop web application using Python modules. ● Use Python and handle cloud resources remotely.
Assessment Method	Quiz / Assignment / ESE
TEXTBOOKS: 1. Gift, N. (2019). Python for DevOps: Learn Ruthlessly Effective Automation. O'Reilly Media. 2. Conway, K., & Smith, B. (2020). Cloud Native Python. O'Reilly Media. 3. Garnaat, M. (2011). Python and AWS Cookbook. O'Reilly Media. 4. Sbarski, P. (2017). Building Serverless Architectures. O'Reilly Media. 5. Murty, J. (2008). Programming Amazon Web Services: S3, EC2, SQS, FPS, and SimpleDB. O'Reilly Media.	

Course Number	ECC 6103
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Advanced Cloud Computing**
Learning Mode	Online

Learning Objectives	This course aims to help the students understand **(a)** how and why cloud systems work and the cloud technologies that manifest these concepts, such as those from Amazon AWS and Microsoft Azure; **(b)** distributed systems concepts like virtualisation, data parallelism, CAP theorem, and performance analysis at scale; **(c)** Big Data programming patterns such as Map-Reduce (Hadoop), Vertex-centric graphs (Giraph), Continuous Dataflows (Storm), and NoSQL storage systems to build Cloud applications; **(d)** Cloud native computing and micro-services
Course Description	This course provides an in-depth understanding of cloud computing, virtualisation, and distributed systems. It covers foundational concepts, advanced techniques, and real-world applications. Students will explore various aspects of cloud infrastructure, virtualisation technologies, distributed algorithms, and cloud-native computing. By the end of the course, students will be equipped with the knowledge and skills to design, implement, and manage cloud-based solutions and distributed systems effectively.
Course Outline	Introduction to Clouds, Virtualization, and Virtual Machines. Network Virtualization and Geo-distributed Clouds. Leader Election in Cloud, Distributed Systems, and Industry Systems. Classical Distributed Algorithms and Industry Systems. Consensus, Paxos, and Recovery in Clouds. Cloud Storage: Key-value Stores/NoSQL Systems and their Use in Industry Systems. Cloud Applications: MapReduce, Spark, and Apache Kafka. Cloud Native Computing and Micro-services.
Learning Outcome	Cloud Computing as a Distributed Systems: Explain and contrast the role of Cloud computing within this space. Cloud Virtualization, Abstractions and Enabling Technologies: Explain virtualisation and their role in elastic computing. Characterise the distinctions between Infrastructure, Platform and Software as a Service (IaaS, PaaS, SaaS) abstractions, and Public and Private Clouds, and analyse their advantages and disadvantages. Programming Patterns for "Big Data" Applications on Cloud: Demonstrate using Map-Reduce, Vertex-Centric and Continuous Dataflow programming models. Application Execution Models on Clouds: Compare synchronous and asynchronous execution patterns. Design and implement Cloud applications that can scale up on a VM and out across multiple VMs. Illustrate the use of NoSQL Cloud storage for information storage. Performance, scalability and consistency on Clouds: Explain the distinctions between Consistency, Availability and Partitioning

	(CAP theorem), and discuss the types of Cloud applications that exhibit these features.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading

- Distributed and Cloud Computing From Parallel Processing to the Internet of Things; Kai Hwang, Jack Dongarra, Geoffrey Fox Publisher: Morgan Kaufmann, Elsevier, 2013.
- Cloud Computing: Principles and Paradigms; Rajkumar Buyya, James Broberg, and Andrzej M. Goscinski Publisher: Wiley, 2011.
- Distributed Algorithms Nancy Lynch Publisher: Morgan Kaufmann, Elsevier, 1996.
- Cloud Computing Bible Barrie Sosinsky Publisher: Wiley, 2011.
- Cloud Computing: Principles, Systems and Applications, Nikos Antonopoulos, Lee Gillam Publisher: Springer, 2012.

Course Number	ECC 6201
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Cloud Computing Architecture**
Learning Mode	Online
Learning Objectives	● Understand the fundamentals of cloud computing architecture and its benefits and challenges. ● Learn about the different types of cloud computing and their applications. ● Develop skills in managing and deploying cloud services. ● Gain knowledge in cloud-based application development. ● Analyze case studies and learn to evaluate if cloud computing is the right fit for specific requirements.

Course Description	This course covers the fundamentals of cloud computing architecture, its benefits, and challenges, as well as the different types and applications of cloud computing.

Course Outline	**MODULE 1 - CLOUD COMPUTING FUNDAMENTALS** ● Cloud Computing definition, private, public and hybrid cloud. ● Cloud types: IaaS, PaaS, SaaS. ● Benefits and challenges of cloud computing, public vs private clouds. ● Role of virtualization in enabling the cloud. ● Business Agility: Benefits and challenges to Cloud architecture. **MODULE 2 - CLOUD APPLICATIONS** ● Technologies and the processes required when deploying web services. ● Deploying a web service from inside and outside a cloud architecture, advantages and disadvantages. **MODULE 3 - MANAGEMENT OF CLOUD SERVICES** ● Reliability, availability and security of services deployed from the cloud. ● Performance and scalability of services. ● Tools and technologies used to manage cloud services deployment. ● Cloud Economics: Cloud Computing infrastructures available for implementing cloud-based services. ● Economics of choosing a Cloud platform for an organization, based on application requirements, economic constraints and business needs (e.g. Amazon, Microsoft and Google, Salesforce.com, Ubuntu and Redhat). **MODULE 4 - APPLICATION DEVELOPMENT** ● Service creation environments to develop cloud-based applications. ● Development environments for service development. ● AWS, Azure, Google App. **MODULE 5 - CLOUD IT MODEL** ● Analysis of Case Studies when deciding to adopt cloud computing architecture. ● How to decide if the cloud is right for your requirements. ● Cloud-based service, applications and development platform deployment so as to improve the total cost of ownership.

Learning Outcome	By the end of this course, students will be able to: ● Understand the fundamental concepts and components of cloud computing architecture. ● Develop skills in deploying and managing cloud services. ● Gain knowledge in cloud-based application development. ● Analyze case studies and evaluate if cloud computing is the right fit for specific requirements. ● Be able to identify and choose the appropriate cloud computing platform for an organization based on application requirements, economic constraints, and business needs.
Assessment Method	Quiz / Assignment / ESE
TEXTBOOKS: 1. "Cloud Computing: Principles and Paradigms" by Rajkumar Buyya, James Broberg, and Andrzej Goscinski 2. "Cloud Computing: A Practical Approach" by Toby Velte, Anthony Velte, and Robert Elsenpeter 3. "Cloud Native: Using Containers, Functions, and Data to Build Next-Generation Applications" by Boris Scholl, Trent Swanson, and Peter Jausovec 4. "Cloud Computing for Dummies" by Judith Hurwitz, Robin Bloor, Marcia Kaufman, and Fern Halper	

Course Number	ECC 6202
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Cloud Security**
Learning Mode	Online
Learning Objectives	Understand the fundamental concepts of cloud security Learn about the various security threats and vulnerabilities in the cloud environment Understand the different technologies and techniques for securing cloud infrastructure Learn about legal and compliance issues related to cloud security Understand the best practices for implementing and managing cloud security
Course Description	This course covers fundamental cloud security concepts, including security threats, vulnerabilities, and technologies for protecting cloud infrastructure. Students will explore legal and compliance issues and learn best practices for implementing and managing cloud security effectively.
Course Outline	**MODULE 1 - INTRODUCTION TO CLOUD SECURITY** ● Overview of cloud computing and cloud security ● Cloud deployment models ● Cloud service models

	● Cloud security risks and challenges ● Security responsibilities in the cloud ● Cloud security best practices **MODULE 2 - CLOUD SECURITY THREATS AND VULNERABILITIES** ● Types of security threats in the cloud ● Cloud security risks and vulnerabilities ● Threats to cloud infrastructure, applications, and data ● Attacks on cloud-based services ● Virtualization security ● Web application security **MODULE 3 - CLOUD SECURITY TECHNOLOGIES** ● Encryption and key management in the cloud ● Identity and access management in the cloud ● Network security in the cloud ● Virtualization security technologies ● Cloud-based security solutions **MODULE 4 - CLOUD SECURITY MANAGEMENT** ● Security governance in the cloud ● Compliance and regulatory issues in the cloud ● Security incident response in the cloud ● Cloud security monitoring and auditing **MODULE 5 - CLOUD SECURITY BEST PRACTICES** ● Secure configuration of cloud services and infrastructure ● Managing security in the cloud ● Training and awareness for cloud security ● Disaster recovery and business continuity in the cloud.
Learning Outcome	● By the end of this course, students will be able to: ● Understand the concepts and principles of cloud security. ● Identify security threats and vulnerabilities in the cloud environment. ● Analyze and evaluate security requirements for cloud infrastructure. ● Implement security measures to protect cloud infrastructure and applications. ● Manage and monitor cloud security. ● Understand legal and compliance issues related to cloud security.
Assessment Method	Quiz / Assignment / ESE

TEXTBOOKS:

1. "Cloud Computing Security: Foundations and Challenges" by John R. Vacca, Syngress (2016)
2. "Cloud Security Automation: Get to secure faster in the cloud" by Prashant Priyam, Packt Publishing (2018)
3. "Building a Comprehensive IT Security Program: Practical Guidelines and Best Practices" by Jeremy Wittkop, Syngress (2016)

Course Number	ECC 6203
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Advanced Edge Computing**
Learning Mode	Online
Learning Objectives	Upon successful completion of this course, students will be able to: **(a)** understand the fundamental concepts and limitations of cloud computing and identify the advantages of edge computing; **(b)** describe various edge computing architectures and differentiate them from traditional cloud models; **(c)** comprehend the principles of distributed systems as they apply to edge computing environments; **(d)** explore the functionalities of edge data centers and lightweight edge clouds; **(e)** deploy and manage containerized applications using Docker and Kubernetes in edge computing contexts; and **(f)** implement and evaluate edge storage systems and end-to-end edge pipelines utilising MQTT and Kafka, as well as investigate advanced edge computing technologies for real-world applications.
Course Description	This course delves into the emerging field of edge computing, providing a comprehensive understanding of its architectures, systems, and technologies. Students will explore the limitations of traditional cloud computing and learn about the advantages and applications of edge computing. The course covers key concepts in distributed systems, edge data centers, and lightweight edge clouds and includes hands-on experience with Docker, Kubernetes, and edge storage systems. Additionally, students will gain insights into end-to-end edge pipelines using MQTT and Kafka and examine advanced edge computing technologies. By the end of the course, students will be equipped with the knowledge and skills to design, implement, and manage edge computing solutions.

Course Outline	Cloud Computing Basics.Edge Computing basics. Edge Computing Use-Cases, Benefits. Different Types of Edge. Edge Deployment Modes. Edge Computing in 5G, Multi-access Edge Computing (MEC) and Mobile Edge Computing.
Learning Outcome	● Critically evaluate advanced edge computing architectures, such as hierarchical, mesh, and hybrid models, considering their suitability for specific use cases and environments. ● Analyse emerging technologies and trends in advanced edge computing, such as edge AI, blockchain, and serverless computing, and assess their potential impact. ● Design and implement innovative edge computing solutions that leverage advanced techniques, such as federated learning, edge caching, and dynamic resource allocation. ● Evaluate the performance and scalability of advanced edge computing systems using benchmarking, simulation, and experimentation. ● Investigate advanced techniques for ensuring security, privacy, and data integrity in edge computing ecosystems, such as secure enclaves, encryption, and access control mechanisms. ● Explore specialised applications of advanced edge computing in domains such as healthcare, smart cities, and autonomous systems, analysing their requirements and challenges.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading

1. Fog and Edge Computing: Principles and Paradigms, Rajkumar Buyya (Editor), Satish Narayana Srirama (Editor), Wiley, 2019.
2. Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wiley, 2011.
3. Cloud and Distributed Computing: Algorithms and Systems, Rajiv Misra, Yashwant Patel, Wiley 2020.
4. Besides these books, we will provide Journal papers as references.

Course Number	ECC 6301
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Cloud Strategy Planning & Management**
Learning Mode	Online

Learning Objectives	● Understand the importance of developing a cloud computing-based IT strategy to deliver on strategic business objectives ● Explore the role of IT leaders in planning and managing IT strategic development in the organization ● Analyze various business strategy models to gain competitive advantage for organizations ● Learn the best practices for managing resources and realizing benefits from Private/Public Cloud IT services
Course Description	This course emphasizes developing a cloud computing-based IT strategy to meet business objectives and explores the role of IT leaders in strategic planning and management. It covers business strategy models for gaining competitive advantage and best practices for managing resources and leveraging private/public cloud IT services.

Course Outline	**MODULE 1: Developing Business Strategy** Investigating business strategy models to gain competitive advantage for organizations, SWOT/PEST, Economies of scale, Porter's 3 Strategies and 5 Competitive Forces, D'Aveni's hyper-competition models **MODULE 2: Strategic IT Leadership in the Organization** Roles of the strategic IS/IT leaders such as Chief Information Officer (CIO) and the Chief Technology Officer (CTO) in planning and managing IT Strategic development in the organization **MODULE 3: Planning a Cloud Computing-based IT Strategy** Developing an IT strategy to deliver on strategic business objectives in the business strategy. IT Project planning in the areas of ITaaS, SaaS, PaaS and IaaS are essential in delivering a successful strategic IT Plan **MODULE 4: SOA and Business Agility** Shared services delivered by a Service Oriented Architecture (SOA) in a Private or Public Cloud. Services, Databases, and Applications on demand The effect on Enterprise Architecture and its traditional frameworks such as Zachman and The Open Group Architecture Framework (TOGAF) **MODULE 5: Benefit Realization and IT Governance** Managing resources (people, process, technology), to realize benefit from Private/Public Cloud IT services (IaaS, PaaS, PraaS, SaaS) Gartner's 5 pillars of benefit realization IT governance as a service in measuring the delivery of IT Strategy from Cloud IT Services using Sarbannes Oxley (CobiT) and other commonly-used approaches
Learning Outcome	By the end of this course, students will be able to: ● Develop an IT strategy to deliver on strategic business objectives ● Understanding of the role of IT leaders in planning and managing IT strategic development in the organization ● Acquire knowledge of various business strategy models to gain competitive advantage for organizations. ● Acquire knowledge of best practices for managing resources and realizing benefits from Private/Public Cloud IT services.

Assessment Method	Quiz / Assignment / ESE
TEXTBOOKS: 1. "Cloud Computing: Principles, Systems and Applications" by Nick Antonopoulos and Lee Gillam 2. "Enterprise Cloud Computing: A Strategy Guide for Business and Technology Leaders" by Brian J. Salkowski and Jay J. Heiser 3. "Cloud Computing: From Beginning to End" by Mr. Ray J Rafaels 4. "Cloud Computing for Business: The Open Group Guide" by Chris Harding	

Course Number	ECC 6302
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 PowerBI. ● 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 PowerBI. ● 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	1. Students will be able to describe the benefits and challenges of data virtualization and how it differs from traditional data integration approaches. 2. 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. 3. Students will be able to design effective dashboards using popular dashboard tools and connect virtual data sources to create interactive visualizations. 4. 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 Virtualization: Going Beyond Traditional Data Integration to Achieve Business Agility (Judith R. Davis, Robert Eve, and Ramesh Chakkoli)

3. Data Visualization: A Practical Introduction (Kieran Healy)

4. The Big Book of Dashboards: Visualizing Your Data Using Real-World Business Scenarios (Steve Wexler, Jeffrey Shaffer, and Andy Cotgreave)

Course Number	ECC 6303
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Distributed Systems**
Learning Mode	Online

Learning Objectives	● To introduce the fundamental concepts of parallel computing and distributed systems. ● To develop an understanding of the structures of parallel and distributed systems. ● To explore the different algorithms and programming techniques used in parallel and distributed systems. ● To analyze the performance, synchronization, coordination, and fault tolerance of distributed systems.
Course Description	Gain foundational knowledge in parallel computing and distributed systems, exploring their structures, algorithms, and programming techniques. Analyze performance, synchronization, coordination, and fault tolerance to optimize distributed system designs for robustness and efficiency.
Course Outline	**Module 1: Introduction to Parallel and Distributed Systems** ● Introduction to parallel computing and distributed systems. ● Solving problems in parallel. ● Structures of parallel and distributed systems. ● Instruction level parallel processing. ● Performance evaluation of parallel and distributed systems. **Module 2: Communication and Network Protocols** ● Characterization of distributed systems. ● Communication and computer networks. ● Distributed processing. ● Distributed operating systems. ● Client-server communications. **Module 3: Distributed Systems Services** ● Remote procedure calls. ● File service. ● Name service. **Module 4: Fault Tolerance and Security** ● Distributed transactions and concurrency control. ● Fault tolerance and security. ● Synchronization and coordination. ● Distributed algorithms and research issues.

Learning Outcome	● Students will be able to describe the basic concepts and structures of parallel and distributed systems. ● Students will be able to implement parallel algorithms and programming techniques to solve problems in distributed systems. ● Students will be able to analyze the performance and synchronization of distributed systems. ● Students will be able to design fault-tolerant distributed systems.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading

Distributed Systems: Concepts and Design" by George Coulouris, Jean Dollimore, and Tim Kindberg. Published by Pearson Education.

"Parallel Computing: Architectures, Algorithms and Applications" by Kai Hwang and Jack Dongarra. Published by McGraw-Hill Education.

"Distributed Systems: Principles and Paradigms" by Andrew S. Tanenbaum and Maarten Van Steen. Published by Pearson Education.

"Distributed Algorithms" by Nancy Lynch. Published by Morgan Kaufmann Publishers.

Course Number	ECC 6401
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Meta Learning**
Learning Mode	Online
Learning Objectives	This course aims to help the students (a) Gain a solid understanding of the foundational principles of meta-learning, including model evaluation, basic machine learning concepts, and their limitations. (b) Delve into advanced techniques such as deep learning, transfer learning, and multitask learning, and understand how these methodologies enhance meta-learning capabilities. (c) Develop proficiency in key meta-learning strategies, including model-based, metric-based, and optimization-based approaches, and familiarize yourself with advanced architectures like memory-augmented networks and conditional sequential neural networks (CSNNs). (d) Apply meta-learning techniques to practical applications in various domains, such as computer vision, natural language processing (NLP), reinforcement learning, healthcare, recommendation

	systems, and climate science, demonstrating the ability to solve complex real-world problems.
Course Description	This comprehensive course provides an in-depth overview of meta-learning, guiding students from foundational principles to advanced techniques. The curriculum begins with the basics of model evaluation, machine learning concepts, and their inherent limitations. Students will then explore advanced topics such as deep learning, transfer learning, and multitask learning, gaining a robust understanding of how these methodologies enhance the capabilities of meta-learning systems.Key meta-learning strategies are thoroughly examined, including model-based, metric-based, and optimization-based approaches. The course features advanced architectures like memory-augmented networks and conditional sequential neural networks (CSNNs), showcasing their roles in improving learning efficiency and effectiveness.Practical applications of meta-learning are highlighted across various fields, including computer vision, natural language processing (NLP), reinforcement learning, healthcare, recommendation systems, and climate science. These examples demonstrate the versatility and power of meta-learning in addressing complex, real-world problems.By the end of the course, students will be equipped with a robust understanding of meta-learning principles and techniques, enabling them to leverage these advanced methodologies to solve intricate problems across diverse domains.
Course Outline	Meta-Learning Basics and Background, Evaluation of Meta learning, Model-Based Meta-Learning Approaches, Metric-Based Meta-Learning Approaches, Optimization-Based Meta-Learning Approaches

Learning Outcome	1. Understand and articulate the foundational principles of meta-learning 2. Apply probabilistic modeling and Bayesian inference to quantify uncertainty and improve model robustness in decision-making processes. 3. Analysis of Optimization-Based Meta-Learning Approaches. 4. Explore and address new challenges in emerging applications
Assessment Method	Quiz / Assignment / ESE

Textbook:

1. Zou, L., 2022. *Meta-learning: Theory, algorithms and applications*.
2. Brazdil, P., Van Rijn, J.N., Soares, C. and Vanschoren, J., 2022. *Metalearning: applications to automated machine learning and data mining* (p. 346).

Course Number	ECC 6402
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Service Oriented Architecture & Web Security**
Learning Mode	Online
Learning Objectives	● To provide an overview of XML Technology and modeling databases in XML. ● To provide an overview of Service Oriented Architecture and Web services and their importance. ● To introduce Security solutions in XML and Web Services and to introduce Security standards for Web Services.
Course Description	Explore XML technology and database modeling, along with an introduction to Service Oriented Architecture (SOA) and Web services, emphasizing their significance in modern IT landscapes. Delve into XML and Web services security solutions, covering essential standards and best practices for securing web-based applications.
Course Outline	**Module 1: XML TECHNOLOGY** ● Introduction to XML and its usage in Web technology ● Name Spaces and their usage in XML ● XML Document Structure ● Structuring with Schemas and DTD ● Modeling Databases in XML ● XQuery **Module 2: SOA BASICS** ● Service Oriented Architecture (SOA) ● Comparison of SOA with Client-Server and Distributed architectures ● Characteristics and Benefits of SOA ● Principles of Service Orientation ● Service Layers ● Business Process Management **Module 3: WEB SERVICES** ● SOA and Web Services ● Web Services Protocol Stack ● Service descriptions ● WSDL (Web Services Description Language) ● Messaging with SOAP (Simple Object Access Protocol) ● Service discovery ● UDDI (Universal Description, Discovery, and Integration) ● Service-Level Interaction patterns ● XML and Web Services ● Enterprise Service Bus ● .NET and J2EE Interoperability **Module 4: WS TECHNOLOGIES AND STANDARDS**

	● Web Services Technologies: JAX-RPC, JAX-WS ● Web Service Standards: WS-RM (Web Services Reliable Messaging), WS-Addressing, WS-Policy ● Service Orchestration and Choreography ● Composition Standards: BPEL (Business Process Execution Language) ● Service Oriented Analysis and Design **Module 5: XML AND WS SECURITY** ● XML Security Overview ● Canonicalization ● XML Security Framework ● XML Encryption ● XML Signature ● XKMS (XML Key Management Specification) Structure ● Web Services Security ● XACML (eXtensible Access Control Markup Language) ● WS-Security
Learning Outcome	By the end of this course, students will be able to: ● Understand the basics of XML. ● Learn the concepts of SOA and Web services, some of the prevailing standards and technologies of Web Services. ● Learn the approaches for providing security for XML documents as well as messages exchanged among Web Services.
Assessment Method	Quiz / Assignment / ESE

TEXTBOOKS:

1. Ron Schmelzer et al. "XML and Web Services", Pearson Education, 2008. (Unit 1 and 3)
2. Thomas Erl, " Service Oriented Architecture: Concepts, Technology, and Design", Pearson Education, 2005 (Unit 2, 3, 4, and 5)
3. Frank P.Coyle, "XML, Web Services and the Data Revolution", Pearson Education, 2002 (Unit 5)
4. James McGovern, Sameer Tyagi, Michael E Stevens, Sunil Mathew, "Java Web Services Architecture", Elsevier, 2011.
5. Mark O' Neill, et al., "Web Services Security", Tata McGraw-Hill Edition, 2003.

Course Number	ECC 6403
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Reinforcement Learning**
Learning Mode	Online
Learning Objectives	This course aims to help the students **(a)** Understand the foundational concepts and mathematical frameworks of reinforcement learning. **(b)** Gain proficiency in key reinforcement learning algorithms, including dynamic programming, Monte Carlo methods, and temporal-difference learning **(c)** Apply deep reinforcement learning techniques to solve complex problems using methods such as deep Q-networks and policy gradient algorithms. **(d)** Explore recent advancements and applications of reinforcement learning, including multi-agent systems and ethical considerations.
Course Description	This specialized course on reinforcement learning aims to give students a deep understanding of the algorithms and methodologies used to train agents to make decisions through trial and error. Students will learn to develop and implement reinforcement learning models by focusing on foundational theories and practical applications. Students will explore key concepts such as Markov decision processes, policy gradients, Q-learning, and deep reinforcement learning through a mix of theoretical lectures, coding exercises, and project-based learning. Upon completion, students will be equipped to design and apply reinforcement learning solutions to complex problems in fields such as robotics, game development, and autonomous systems, enhancing their expertise in this dynamic area of artificial intelligence.

Course Outline	Foundations: Basics of machine learning and reinforcement learning (RL) terminology. Probability Concepts: Axioms of probability, random variables, distributions, and correlation. Markov Decision Process: Introduction to MDPs, Markov property, and Bellman equations. State and Action Value Functions: Concepts of MDP, state, and action value functions. Tabular Methods and Q-networks: Dynamic programming, Monte Carlo, TD learning, and deep Q-networks. Policy Optimization: Policy-based methods, REINFORCE algorithm, and actor-critic methods. Recent Advances and Applications: Meta-learning, multi-agent RL, ethics in RL, and real-world applications.
Learning Outcome	1. Mastery of fundamental principles and mathematical frameworks of reinforcement learning. 2. Proficiency in implementing key reinforcement learning algorithms and techniques. 3. Ability to apply deep reinforcement learning methods to complex, real-world problems. 4. Understanding of recent advancements in reinforcement learning and their ethical implications.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading

- Reinforcement Learning: An Introduction by Richard S. Sutton and Andrew G. Barto, The MIT Press (1 January 1998).
- Deep Reinforcement Learning Hands-On by Maxim Lapan, Packt Publishing Limited (21 June 2018).
- Algorithms for Reinforcement Learning by Csaba Szepesvari, Morgan and Claypool Publishers (2010)
- Deep Reinforcement Learning: Fundamentals, Research and Applications by Hao Dong, Springer Verlag (2020)