Electives for Executive M.Tech CSE

Sl. No.	Subject Code	Elective-I	L	T	P	C
1	ECS 6101	Advanced Cyber Security	3	0	0	3
2	ECS 6102	Data Analytics	3	0	0	3
3	ECS 6103	Cyber Physical Systems	3	0	0	3

Sl. No.	Subject Code	Elective-II	L	T	P	C
1	ECS 6201	Advanced Cloud Computing	3	0	0	3
2	ECS 6202	Advanced Edge Computing	3	0	0	3
3	ECS 6203	Pattern Recognition	3	0	0	3

Sl. No.	Subject Code	Elective-III	L	T	P	C
1	ECS 6301	Artificial Internet of Things	3	0	0	3
2	ECS 6302	Game Theory	3	0	0	3
3	ECS 6303	Quantum Machine Learning	3	0	0	3

Sl. No.	Subject Code	Elective-IV	L	T	P	C
1	ECS 6401	Advanced Time Series Analysis	3	0	0	3
2	ECS 6402	Selected Topics in Wireless Networks	3	0	0	3
3	ECS 6403	High Performance Computing	3	0	0	3

Course Number	**ECS 6101**
Course Credit	L-T-P-C: **3-0-0-3**
Course Title	**Advanced Cyber Security**
Learning Mode	Online
Learning Objectives	To have a clear understanding of security and privacy issues in various aspects of computing, including: Programs, Operating systems, Networks, Web Applications
Course Description	The course covers. security and privacy issues in various aspects of computing, including: Programs, Operating systems, Networks, Web Applications
Course Outline	Introduction to Computer Security and Privacy: security and privacy; types of threats and attacks; methods of defense Basics of cryptography, Authentication & key agreement, Authorization and access control Program Security: nonmalicious program errors; vulnerabilities in code, Secure programs; malicious code; Malware detection Internet security : IPSEC, TLS, SSh, Email security Wireless security: WEP, WPA, Bluetooth security, Web Security: XSS attack, CSRF attack, SQL Injection, DoS attack & defense
Learning Outcome	After completion of this course a student will have (i) Understanding of security issues in computer and networks, (ii) Understanding and analysis of internet security protocols (iii) Understanding and analysis of web security protocols
Assessment Method	Quiz / Assignment / ESE

Textbooks:

1. Computer Security: Principles and Practice: Dr. William Stallings and Lawrie Brown, Pearson
2. O'Reilly Web Application Security by Andrew Hoffman

Course Number	ECS 6102
Course Credit (L-T-P-C)	L-T-P-C: 3-0-0-3
Course Title	**Data Analytics**
Learning Mode	Online
Learning Objective	In this subject, the students will be trained with the knowledge of various computational techniques required for multi-dimensional data analysis such that they are able to apply these techniques in practice through programming, modeling etc.
Course Description	Modern day data is vast and diverse owing to their different acquisition systems and medium. This course aims to give an in-depth view to different data generation/acquisition mechanisms over diverse domains and the challenges incurred. It will discuss the role of computational data analysis techniques to understand and mathematically model data formation process. It will also teach them about the various data processing techniques required to manipulate and operate data to suit various objectives.
Course Outline	**Module1:** Understanding multi-dimensional data formation from physical acquisition devices with example cases in Remote Sensing, Geoscience, Medical sciences. Drawbacks and challenges in data acquisition, Necessity for computational modelling and analysis of data. **Module 2:** Mathematical models for data formation and analysis, Probability models, Linear inverse optimization models, L1-L2 Regularizers, Minimizers, Cascade Modelling, Multiscale Modelling, Machine Learning models. **Module 3:** Data Interpretation: Handling missing/corrupted data, Handling outliers, Imputation techniques, Interpolation techniques, Curve based approximation, non-convex optimization, sparse regularizers, Non-convex minimizers, Machine learning based. **Module 4:** Data compression: Necessity, Applications, Lossless compression techniques, Lossy compression techniques, JPEG compression, Machine learning based. **Module 5:** Statistical Models, Data preprocessing techniques in Machine learning, Signal processing techniques for multi dimensional data, Application in various domains.

Learning Outcome	After completion of course, students will be able to ● Understand data formation/generation process and the role of computational techniques in analyzing those data. ● Apply the Mathematical principles behind computational techniques for data analysis. ● Understand the utilities of statistical models and ML models in data analysis.
Assessment Method	Quiz / Assignment / ESE

Suggested Readings:

1. Signal Processing: A Mathematical Approach, Charles L. Byrne, Second Edition, Chapman & Hall, 2014.
2. Digital Functions and Data Reconstruction: Digital-Discrete Methods, Li M Chen, Springer, 2013.
3. Machine Learning with Neural Networks: An Introduction for Scientists and Engineers, Bernhard Mehlig, Cambridge University Press, 2021
4. Signal Processing and Machine Learning with Applications, Michael M. Richter, Sheuli Paul, Veton Këpuska, Marius Silaghi, Springer Cham, 2022
5. Data Compression: The Complete Reference, David Solomon, 4th Edition, Springer, 2007

Course number	**ECS 6103**
Course Credit	L-T-P-C:**3-0-0-3**
Course Title	**Cyber Physical Systems**
Learning Mode	Online
Learning Objectives	To learn how to model and design the joint dynamics of software, networks, and physical processes., To develop the skills to realize embedded systems that are safe, reliable, and efficient in their use of resources., To learn to think critically about technologies that are available for achieving such joint dynamics.
Course Description	This course will provide an overview of modeling, building, analyzing methods for cyber physical systems.
Course Outline	Models of computation: finite state machines, threads, ordinary differential equations, hybrid systems, actors, discrete-events, data flow Basic analysis, control, and systems simulation: Bisimulations, reachability analysis, controller synthesis, approximating continuous-time systems. Interfacing with the physical world: sensor/actuator modeling and calibration, concurrency in dealing with multiple real-time streams, handling numerical imprecision in software Mapping to embedded platforms: real-time operating systems, execution time analysis, scheduling, concurrency Distributed embedded systems: Protocol design, predictable networking, security
Learning Outcome	1. Basic understanding of cyber physical systems 2. To develop the skills to realize embedded systems that are safe, reliable, and efficient in their use of resources., 3. To learn to think critically about technologies that are available for achieving such joint dynamics.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading:

- Introduction to Embedded Systems - A Cyber-Physical Systems Approach, Second Edition, by E. A. Lee and S. A. Seshia, 2015
- Vahid, F. and T. Givargis (2010). Programming Embedded Systems - An Introduction to Time-Oriented Programming, UniWorld Publishing.
- Schaumont, P. R. (2010). A Practical Introduction to Hardware/Software Codesign, Springer.
- E. A. Lee and P. Varaiya, *Structure and Interpretation of Signals and Systems*, Addison-Wesley, 2003.

Course Number	ECS 6201
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	ECS 6202
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	ECS 6203
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Pattern Recognition**
Learning Mode	Online
Learning Objectives	This course aims to help the students (a) Understand the advanced topics of pattern recognition, including classification and clustering methods. (b) To understand the advanced topics of feature selection, multi-label classification. (c) Apply advanced pattern recognition algorithms to practical applications in image processing, speech recognition, and data mining.
Course Description	This course on pattern recognition aims to equip students with the advanced topics of classification, clustering, and feature selection. By focusing on advanced topics, students will develop the ability to implement and evaluate various pattern recognition algorithms. Students will enhance their understanding of advanced topics of classification, clustering, statistical methods, and data preprocessing techniques through interactive lectures, exercises, and projects. Upon completion, students will be proficient in designing and applying advanced pattern recognition systems for applications such as image processing, text mining, speech recognition, and data mining, thereby enhancing their analytical and problem-solving capabilities in diverse domains.
Course Outline	Introduction and motivation of advanced pattern recognition Modern Classification Methods, Random fields, Pattern recognition based on multidimensional models Contextual classification, Hidden Markov models, Multi-classifier systems Advanced parameter estimation methods, Advanced Unsupervised classification, Modern methods of feature selection. Data normalization and invariants, Benchmarking. Analysis and synthesis of image information. Applications od pattern recognition in Text Processing and Healthcare.

Learning Outcome	• Mastery of advanced concepts in pattern recognition. • In-depth understanding of various advanced algorithms across different pattern recognition paradigms. • Comprehensive knowledge of advanced aspects of classification, clustering, feature selection, feature extraction, and projection techniques. • Ability to apply advanced pattern recognition algorithms to real-world projects
Assessment Method	Quiz / Assignment / ESE

Textbooks:

1. "Pattern Recognition and Machine Learning" by Christopher M. Bishop, Springer, 2006.
2. "Pattern Classification" by Richard O. Duda, Peter E. Hart, and David G. Stork, Wiley, 2001.
3. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy, MIT Press, 2012.
4. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016.
5. "Introduction to Statistical Pattern Recognition" by Keinosuke Fukunaga, Academic Press, 1990.

Course Number	ECS 6301
Course Credit	3-0-0-3
Course Title	**Artificial Internet of Things**
Learning Mode	Online
Learning Objectives	● Gain a comprehensive understanding of the convergence of Artificial Intelligence (AI) and Internet of Things (IoT), including basic concepts, architectures, and applications. ● Learn various AI techniques and their applications in IoT, including machine learning, deep learning, and data analytics. ● Develop skills in designing and implementing IoT systems, integrating sensors, and managing data flow. ● Understand the processes for collecting, storing, processing, and analyzing IoT data using AI techniques. ● Identify and mitigate security risks and privacy concerns in AIoT systems. ● Analyze various real-world applications of AIoT in industries such as healthcare, smart cities, agriculture, and manufacturing. ● Understand the regulatory and ethical considerations related to AIoT technologies and their deployment.
Course Description	This course provides an in-depth exploration of the convergence of Artificial Intelligence (AI) and the Internet of Things (IoT), known as AIoT. It covers the fundamental principles and technologies of both AI and IoT, demonstrating how they can be integrated to create intelligent, autonomous systems. Students will learn about IoT architecture, AI algorithms, machine learning, data analytics, and the implementation of AI-driven IoT solutions. Through hands-on projects and real-world case studies, students will gain practical experience in developing smart applications for various domains such as smart cities, healthcare, industrial automation, and smart homes.

Course Outline	● Introduction to AIoT, Intersection of AI and IoT, Benefits and challenges of AIoT ● Fundamentals of IoT, IoT Architecture and Protocols, Layers of IoT architecture, Communication protocols and standards, IoT Devices and Sensors ● Fundamentals of Artificial Intelligence, Machine Learning and Deep Learning, Overview of AI tools and frameworks ● AIoT System Architecture, Components and Designing AIoT, Edge Computing in AIoT, Edge vs. cloud computing, AI Models for IoT ● Data Management in AIoT, Data Processing and Analysis, Handling large-scale IoT data, Big data technologies and platforms ● AIoT Applications and Use Cases: Smart Homes and Buildings, Healthcare and Wearables, Industrial IoT (IIoT), Smart Cities and Transportation ● AIoT Platforms and Tools: AI Development Tools, Case Studies of AIoT Solutions, AIoT Project Development, Future Trends and Innovations in AIoT
Learning Outcome	At the end of course, students will have achieved the following learning objectives. ● Students should grasp the foundational concepts of AI and IoT, including machine learning algorithms, data analytics, sensor technologies, and network protocols. ● Ability to integrate AI algorithms with IoT devices and platforms to create intelligent systems capable of data collection, analysis, and decision-making in real-time. ● Proficiency in developing AI-driven IoT applications, including sensor data processing, predictive analytics, anomaly detection, and automation. ● Awareness of security challenges and solutions in AIoT systems, including data privacy, authentication, encryption, and intrusion detection. ● Knowledge of optimization techniques for AIoT systems to enhance performance, scalability, and energy efficiency.
Assessment Method	Quiz / Assignment / ESE

Suggested Reading

- Olivier Hersent, David Boswarthick, and Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley
- Maciej Kranz, Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry, Wiley
- John Paul Mueller and Luca Massaron, Machine Learning for the Internet of Things: Practical Guide, Packt.

Course Number	ECS 6302
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Game Theory**
Learning Mode	Online
Learning Objectives	1. Learn the principles of decision theory and its relevance to game theory. 2. Understand and analyze extensive form games, including game trees and backward induction. 3. Identify and compute pure and mixed strategy Nash equilibria. 4. Analyze matrix games, specifically two-player zero-sum games. 5. Understand Bayesian games and apply Bayesian equilibrium concepts to games with incomplete information. 6. Analyze and compute subgame perfect equilibria in dynamic games. 7. Explore coalitional games, including the core and the Shapley value. 8. Explore auction theory and its various models and applications. 9. Utilize game theory concepts in practical applications such as IoT, wireless networks, and cloud computing.
Course Description	This course aims to establish a solid foundation in both game theory and mechanism design, enabling participants to apply these principles rigorously to solve problems. By the end of the course, students will be equipped to model real-world scenarios using game theory, analyze these scenarios with game-theoretic concepts, and design effective and robust solutions, including mechanisms, algorithms, and protocols suitable for rational and intelligent agents.
Course Outline	**Non-cooperative Game Theory:** Decision theory, Extensive Form Games, Strategic Form Games, Dominant Strategy Equilibria, Pure Strategy Nash Equilibrium, Mixed Strategy Nash Equilibrium, Computation of Nash Equilibrium, Complexity of Computing Nash Equilibrium, Matrix Games (Two Player Zero-sum Games), Bayesian Games, Subgame Perfect Equilibrium. **Cooperative Game:** Correlated Strategies and Correlated Equilibrium, Two Person Bargaining Problem, Coalitional Games, Core, Shapley Value. **Mechanism Design:** Introduction to Mechanism Design, Social Choice Functions and their properties, Incentive Compatibility, Auction theory and its variants. **Applications:** IoT, Wireless Networks, Cloud Computing

Learning Outcome	By the end of this course, students will be able to: ● Describe the principles of decision theory and its importance in game theory. ● Formulate and solve strategic form games, identifying dominant strategy equilibria and Nash equilibria. ● Analyze and solve matrix games, particularly two-player zero-sum games. ● Formulate Bayesian games and determine Bayesian equilibria for games with incomplete information. ● Compute subgame perfect equilibria for dynamic games using appropriate techniques. ● Apply the concepts of correlated strategies and correlated equilibria in cooperative settings. ● Analyze and solve two-person bargaining problems. ● Analyze social choice functions and their properties, focusing on incentive compatibility. ● Utilize game theory concepts to address practical problems in IoT, wireless networks, and cloud computing.
Assessment Method	Quiz / Assignment / ESE

Textbook:

1. M. Osborne, An Introduction to Game Theory, Oxford University Press.
2. Y. Narahari. Game Theory and Mechanism Design. IISc Press and the World Scientific.

Reference Book:

3. M. Maschler, E. Solan, and S. Zamir, Game Theory. Cambridge University Press.
4. D. Niyato, & W. Saad. Game theory in wireless and communication networks. Cambridge University Press.

Course Number	ECS 6303
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Quantum Machine Learning**
Learning Mode	Online
Learning Objectives	This course aims to help the students (a) proficiency in implementing and applying classical machine learning algorithms, including classification, regression, gradient descent, and neural networks. (b) grasp the foundational principles of quantum computing, quantum states, qubits, and basic quantum operations.(c) advanced quantum algorithms and their applications in machine learning and computational tasks. (d) gain practical experience in implementing quantum algorithms and simulating quantum processes.
Course Description	This course offers a comprehensive exploration of machine learning (ML) and quantum computing (QC) principles, preparing students to navigate the intersection of classical and quantum computational paradigms. Students will master classical ML techniques including classification, regression, neural networks, and optimization methods like gradient descent. In the quantum computing segment, foundational concepts such as quantum states, qubits, and basic quantum operations (e.g., Hadamard gates) will be covered, alongside encoding classical data on quantum systems and implementing basic quantum algorithms. Advanced topics include variational quantum algorithms, quantum support vector machines, the HHL algorithm for linear systems, and quantum neural networks. Through lectures, practical exercises using quantum programming frameworks, and real-world applications, students will develop a dual proficiency in classical ML and quantum computing, equipping them for roles in research, development, or applications across industries leveraging emerging quantum technologies.
Course Outline	Overview of Machine Learning, Quantum Circuit, Variational quantum algorithm, Quantum Neural Network
Learning Outcome	1. Understanding of Machine Learning and Quantum Computing Fundamentals. 2. Apply the concept of feature vectors, encode data in Quantum computing. 3. Analysis of Variational quantum algorithms to solve complex problems. 4. Implementation and analysis of advanced quantum machine learning algorithms.
Assessment Method	Quiz / Assignment / ESE

Textbooks:

1. Nielsen, M.A. and Chuang, I.L., 2010. *Quantum computation and quantum information*.
2. Schuld, M. and Petruccione, F., 2021. *Machine learning with quantum computers* (Vol. 676). Berlin.
3. Relevant research articles.

Course Number	ECS 6401
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Advanced Time Series Analysis**
Learning Mode	Online
Learning Objectives	● This course on advance time series will teach both the fundamental concepts time series analysis, as well as recent trends in time series analysis. ● Students will learn to design successful time series data applications with sequential Neural Networks. ● Deploy Nonlinear Auto-regressive Network with Exogenous Inputs. ● Adapt Deep Neural Networks for Time Series Forecasting and classification
Course Description	This course covers classical time series methods, univariate stationary processes, and vector autoregressive processes, along with machine learning and deep learning techniques for stock price prediction and risk management.
Course Outline	Introduction to classical time series methods, time series Virtualization Univariate Stationary Processes; Granger Causality; Vector Autoregressive Processes Nonstationary Processes; Cointegration; Cointegration in Single Equation Models: Representation,Estimation and Testing. Applied Predictive Modeling Techniques; Autoregressive Conditional Heteroskedasticity. Finance and Algorithmic trading: Machine Learning and Deep Learning in Stock Price Prediction Machine Learning, Deep Learned Time series Analysis, Risk and Portfolio Management Practical Applications and Deployment of models; applications of convolutional neural network (CNN) and long-and-short-term memory (LSTM) network architectures; designing predictive models for financial time series data Stock Price Prediction using Deep Learning and Natural Language Processing
Learning Outcome	At the end of the course, students will have achieved the following learning objectives. ● problems relating to obtaining, cleaning, simulating, and storing time series data. ● Variety of modeling techniques that can be used for recent time series analysis. ● techniques of financial time series analysis and forecasting financial series using statistical, econometric, machine learning, and deep learning approaches. ● Apply more recently developed methods, such as machine learning and neural network, to time series data, highlighting the challenges of data processing and data layout when time series data is used for fitting models.

Assessment Method	Quiz / Assignment / ESE

Textbooks:

- Kirchgässner, Gebhard, Jürgen Wolters, and Uwe Hassler. *Introduction to modern time series analysis*. Springer Science & Business Media, 2012.
- Lazzeri, F. (2020). *Machine learning for time series forecasting with Python*. John Wiley & Sons.
- Jaydip, Sen, and Mehtab Sidra. *Machine Learning in the Analysis and Forecasting of Financial Time Series*. 2022.
- Gharehbaghi, Arash. *Deep Learning in Time Series Analysis*. CRC Press, 2023.

Course Number	ECS 6402
Course Credit	L-T-P-C: 3-0-0-3
Course Title	**Selected Topics in Wireless Networks**
Learning Mode	Online
Learning Objectives	In this subject, the students will be trained with the knowledge of 802.11 wireless networks, including protocol knowledge and the associated security vulnerabilities.
Course Description	In the consumer, industrial, and military sectors, 802.11-based wireless access networks have been widely used due to their convenience. This application, however, is reliant on the unstated assumptions of availability and anonymity. The management and media access protocols of 802.11 may be particularly vulnerable to malicious denial-of-service (DoS) and various security attacks. This course analyzes these 802.11-specific attacks, including their applicability, effectiveness, and proposed low-cost implementation improvements to mitigate the underlying vulnerabilities.
Course Outline	Introduction to Wireless Networks: Basic principles, types of wireless networks (Wi-Fi, Bluetooth, cellular), and network topologies. Wireless Communication Fundamentals: Radio frequency, signal propagation, modulation techniques, and interference management. Network Protocols and Standards: IEEE 802.11 (Wi-Fi), IEEE 802.15 (Bluetooth), and cellular standards (2G, 3G, 4G, 5G). Network Design and Architecture: System design, frequency reuse, and resource allocation. Mobility and Handoff: Techniques for managing mobility, handoff processes, and roaming. Security in Wireless Networks: Security protocols, encryption, and threat mitigation. Emerging Technologies: Overview of 6G, IoT, in-network caching
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the fundamentals of 802.11 wireless networks 2. Describe the WLAN services-association, disassociation, re-association, distribution, integration, authentication, de authentication and data delivery services 3. Comprehend the vulnerabilities associated with 802.11 protocol.
Assessment Method	Quiz / Assignment / ESE

Text Books and References:

1. "Wireless Communications: Principles and Practice" by Theodore S. Rappaport (2nd Edition)
2. "802.11 Wireless Networks: The Definitive Guide" by Matthew S. Gast (2nd Edition)
3. "Wireless Communications & Networks" by William Stallings (2nd Edition)
4. "Wireless Communications: Principles and Practice" by Andreas F. Molisch (2nd Edition)
5. "Fundamentals of Wireless Communication" by David Tse and Pramod Viswanath (1st Edition)
6. "Next Generation Wireless LANs: 802.11n and 802.11ac" by Eldad Perahia and Robert Stacey (2nd Edition)

7. "Wireless Networking: Understanding Internetworking Challenges" by Anurag Kumar, D. Manjunath, and Joy Kuri (1st Edition)
8. "Wireless Communications: Principles and Practice" by Kaveh Pahlavan and Prashant

Course Number	ECS 6403
Course Credit	3-0-0-3
Course Title	**High Performance Computing**
Learning Mode	Online
Learning Objectives	The course is designed to provide basic understanding of structure, and function of various building blocks of high performance Computing System. Students will be able to design various functional units and components and to identify the elements of modern GPUs and their impact on processor/GPU/TPU and parallel architecture design including memory
Course Description	Using a set of fundamental techniques and technologies, the high performance systems theme broadly explains how computing platforms work at various levels of abstraction, including both software and hardware. The course introduces HPS architecture with focus on parallel architectures

Course Outline	● Computer types, Structure with basic computer components - instruction sets of some common CPUs/GPUs; ● Parallel Processing Concepts: a) Levels of parallelism (instruction, transaction, task, thread, memory, function) ● Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-driven Computation etc) c) Architectures: N-wide superscalar architectures, multi-core, multi-threaded ● Parallel Programming with CUDA: a) Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in high performance computing architectures: ● Fundamental Design Issues in Parallel Computing: a) Synchronization b) Scheduling, c) Job Allocation d) Job Partitioning, e) Dependency Analysis,f) Mapping Parallel Algorithms onto Parallel Architectures g) Performance Analysis of Parallel Algorithms ● Power-Aware Computing and Communication: a) Power-aware Processing Techniques ● Advanced Topics:(a) Petascale Computing,(b) Optics in Parallel Computing,(c) Quantum Computers,(d) Recent developments in Nanotechnology and its impact on HPC
Learning Outcome	The student will be able to : ● Appreciate understanding of the HPC blocks, key terminology, and current industry trends in high performance computer architecture. ● Understand parallel programming and evaluate and compare the architectural features of the state of the art high performance commodity hardware platforms. ● Understand the processor (CPU/GPU/TPU) subsystem. ● Employ concepts of the HPS memory subsystem and hierarchy
Assessment Method	Quiz / Assignment / ESE

Text Books:

[1] "Highly Parallel Computing", by George S. Almasi and Alan Gottlieb

[2] "Advanced Computer Architecture: Parallelism, Scalability, Programmability", by Kai Hwang, McGraw Hill 1993