Annexure-G

Revised Curriculum for Doctor of Philosophy in Computer Science

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF PESHAWAR
SESSION 2024

1 Introduction

The Doctor of Philosophy (PhD) in Computer Science program of the Department of Computer Science is a research-oriented program. The program has been designed in light of the guidelines/models enacted by authorized national bodies and meets global standards. It offers advanced courses in the emerging research areas of computer science followed by intensive research work which allows students to transform themselves into highly skilled researchers capable of working in industry and academia.

2 Rationale of Revision

Computer Science spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in applied fields including machine learning, information management, World Wide Web, bioinformatics, and other exciting areas. Advanced principles, concepts, methods, approaches, and technologies continually evolve and intersect over time to address the ever-changing and diverse landscape of Computer Science. Therefore, the curriculum of a PhD in Computer Science program must be updated regularly to include the latest advancements and technologies, ensuring that students are equipped to meet the evolving demands of the field and software industry, thereby contributing to the country's economic growth. The following notable changes have been made in the existing PhD Computer Science program.

1) List of specializations has been updated.
2) New courses have been added in different categories to train students in the latest technologies of Computer Science. Obsolete courses have been archived.
3) Course titles of the existing courses have been changed, where needed, to clearly reflect their contents.
4) Contents of existing courses have been revised to incorporate topics related to recent trends in Computer Science, to equip students with up-to-date information in Computer Science theory and research.
5) Text and reference books have been updated where needed.
6) New course codes have been allotted to the existing and new courses according to the UOP course code policy in the 800 series.

3 List of Specializations/Research Areas

The specialization/research area of a research scholar will be decided by the Graduate Studies Committee (GSC) at the time of proposal defense. The following table shows the list of specializations in PhD Computer Science at the Department of Computer Science:

S.No.	Name of Specialization/Research Area
1	Artificial Intelligence
2	Cloud Computing
3	Computer Networks
4	Computer Vision
5	Cyber Security
6	Data Science
7	Data Mining
8	Database Systems
9	Digital Transformation
10	Digital Humanism
11	Digital Inclusion
12	Educational Technology
13	E-Governance
14	Human Computer Interaction
15	ICT Accessibility
16	Image Processing
17	Information Retrieval
18	Machine Learning
19	Parallel Computing
20	Real Time Systems
21	Software Engineering
22	Web Engineering
23	Web Semantics
24	Wireless Networks
25	Wireless Sensor Networks

4 Courses Details

4.1 Complete List of PhD Courses with New Course Codes

S. No.	New Course Code	Old Course Code	Course Title	Credit Hours	Course Details
1	CS801	CS8101	Computational Models of Syntax and Discourse	3	Revised
2	CS802	CS8102	Advanced Natural Language Engineering	3	Revised
3	CS803	CS8103	Neural Machine Translation	3	Revised
4	CS804	CS8104	Advanced Wireless Sensor Networks	3	Revised
5	CS805	CS8106	Advanced Network Security	3	Revised
6	CS806	CS8107	Information & Web Semantics	3	Revised
7	CS807	CS8108	Advanced Ontology Engineering	3	Revised
8	CS808	CS8109	Information Visualization and Visual Analytics	3	Revised
9	CS809	CS8110	Topics in Databases	3	Revised
10	CS810	CS8113	Special Topics in Computer Science	3	Revised
11	CS811	CS8115	Topics in Data Warehousing and Business Intelligence	3	Revised
12	CS812	CS8116	Text Mining	3	Revised
13	CS813	CS8117	Topics in Data Mining	3	Revised
14	CS814	CS8118	Topics in Wireless Networks	3	Revised
15	CS815	CS8119	Topics in Cloud Computing	3	Revised
17	CS816	CS8121	Software Reviews and Metrics	3	Revised
18	CS817	CS8122	Advanced Software Architecture	3	Revised
23	CS818	CS8127	New Trends in Software Engineering	3	Revised
24	CS819	CS8128	Context Aware Computing	3	Revised
25	CS820	CS8129	Topics in Digital Forensics	3	Revised
26	CS821	CS8130	Social Web	3	Revised
27	CS822	CS8131	New Trends in Wireless Sensor Networks	3	Revised
28	CS823	CS8132	Topics in Embedded Systems	3	Revised
29	CS824	CS8134	Advanced Middleware for Wireless Sensor Networks and Distributed Systems	3	Revised
30	CS825	CS8135	Topics in Information Security	3	Revised
31	CS826	CS8138	Topics in Real-Time Systems	3	Revised
32	CS827	CS8140	Real-Time Scheduling Theory	3	Revised

S. No.	New Course Code	Old Course Code	Course Title	Credit Hours	Course Details
33	CS828	CS8142	Sustainable Software Engineering	3	Revised
34	CS829	CS8143	Enterprise Architecture and Integration	3	Revised
35	CS830	CS8144	Topics in High Performance Computing	3	Revised
36	CS831	CS8146	Semantic Data Storage and Management	3	Revised
37	CS832	CS8147	Topics in User Experience Design	3	Revised
38	CS833	CS8149	Soft Computing	3	Revised
39	CS834	CS8152	Biomedical Image Processing	3	Revised
40	CS835	CS8155	Topics in Computer Vision	3	Revised
41	CS836	CS8157	Topics in Deep Learning	3	Revised
42	CS837	CS8159	Advanced Human Computer Interaction	3	Revised
43	CS838	CS8160	Advanced Learning Technologies	3	Revised
44	CS839	CS8161	Serious Games	3	Revised
45	CS840	--	Topics in Cyber Security	3	New
46	CS841	--	Emerging Trends in Internet of Things	3	New
47	CS842	--	AI-Enabled Wireless and Mobile Networks	3	New
48	CS843	--	Future Network Technologies	3	New
49	CS844	--	Advanced Federated Learning	3	New
50	CS845	--	Advancements in Large Language Modeling	3	New
51	CS846	--	Text Analytics	3	New
52	CS847	--	Perception Systems for Autonomous Vehicles	3	New
53	CS848	--	Advanced Convolutional Neural Network	3	New
54	CS849	--	Creativity, Innovation and Professional Development in Software Engineering	3	New

4.2 Details of Revisions of Existing Courses

	Course Code	Course Title	Course Code Updated	Course Title Changed	Course Outline Updated	Reference Material Updated
1	CS801	Computational Models of Syntax and Discourse	✓	✓	✓	✓
2	CS802	Advanced Natural Language Engineering	✓	✓	✓	✓
3	CS803	Neural Machine Translation	✓	✓	✓	✓
4	CS804	Advanced Wireless Sensor Networks	✓		✓	✓
5	CS805	Advanced Network Security	✓		✓	✓
6	CS806	Information & Web Semantics	✓		✓	
7	CS807	Advanced Ontology Engineering	✓		✓	
8	CS808	Information Visualization and Visual Analytics	✓	✓	✓	✓
9	CS809	Topics in Databases	✓		✓	
10	CS810	Special Topics in Computer Science	✓		✓	▪✓
11	CS811	Topics in Data Warehousing and Business Intelligence	✓		✓	
12	CS812	Text Mining	✓		✓	✓
13	CS813	Topics in Data Mining	✓		✓	
14	CS814	Topics in Wireless Networks	✓	✓	✓	✓
15	CS815	Topics in Cloud Computing	✓	✓	✓	✓
16	CS816	Software Reviews and Metrics	✓	✓	✓	✓
17	CS817	Advanced Software Architecture	✓		✓	✓
18	CS818	New Trends in Software Engineering	✓		✓	✓
19	CS819	Context Aware Computing	✓		✓	
20	CS820	Topics in Digital Forensics	✓		✓	✓
21	CS821	Social Web	✓		✓	
22	CS822	New Trends in Wireless Sensor Networks	✓		✓	✓
23	CS823	Topics in Embedded Systems	✓	✓	✓	✓
24	CS824	Advanced Middleware for Wireless Sensor Networks and Distributed Systems	✓	✓	✓	✓
25	CS825	Topics in Information Security	✓	✓	✓	✓
26	CS826	Topics in Real-Time Systems	✓	✓	✓	✓
27	CS827	Real-Time Scheduling Theory	✓		✓	✓

	Course Code	Course Title	Course Code Updated	Course Title Changed	Course Outline Updated	Reference Material Updated
28	CS828	Sustainable Software Engineering	✓	✓	✓	✓
29	CS829	Enterprise Architecture and Integration	✓		✓	✓
30	CS830	Topics in High Performance Computing	✓	✓	✓	✓
31	CS831	Semantic Data Storage and Management	✓		✓	
32	CS832	Topics in User Experience Design	✓	✓	✓	✓
33	CS833	Soft Computing	✓		✓	
34	CS834	Biomedical Image Processing	✓	✓	✓	✓
35	CS835	Topics in Computer Vision	✓	✓	✓	✓
36	CS836	Topics in Deep Learning	✓	✓	✓	✓
37	CS837	Advanced Human Computer Interaction	✓		✓	✓
38	CS838	Advanced Learning Technologies	✓		✓	✓
39	CS839	Serious Games	✓		✓	✓

4.3 List of Archived Courses

S. No.	Code	Course Title	Credit Hours
1	CS8105	Network Traffic Engineering	3
2	CS8111	Advanced Object-oriented Methods	3
3	CS8112	Advanced Computer Graphics	3
4	CS8114	Computational Morphology	3
5	CS8120	Emerging Themes in Agile Software Development	3
6	CS8123	Software Engineering Ontologies	3
7	CS8124	Software Process Improvement	3
8	CS8125	Advanced User Interface Design and Development	3
9	CS8126	Software CASE Tools and Applications	3
10	CS8133	Localization techniques in Wireless Sensor Networks	3
11	CS8136	Topics in Computer Networks	3
12	CS8137	Special Topics in Human Language Technology	3

S. No.	Code	Course Title	Credit Hours
13	CS8139	Distributed Real-Time Systems	3
14	CS8141	Smart Device-To-Device Communication	3
15	CS8145	Fault Tolerance in Computing	3
16	CS8148	Ambient Assisted Living	3
17	CS8150	Modeling and Simulation	3
18	CS8151	WSN Security and QoS	3
19	CS8153	Face and Gesture Recognition	3
20	CS8154	Deep Learning in Computer Vision	3
21	CS8156	Medical Image Registration	3
22	CS8158	Deep Learning in Natural Language Processing	3

5 Course Contents

Course Name:	Computational Models of Syntax and Discourse
Course Code:	CS801
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course delves into advanced computational models for analyzing syntax and discourse in natural language processing (NLP). It covers state-of-the-art techniques and theoretical foundations for building and evaluating models that handle complex syntactic structures and discourse phenomena. Students will engage with both the theoretical aspects and practical applications of these models, exploring recent advancements and research trends in the field.

Course Objectives: The objectives of the course are as follows:

- Advanced computational models for syntactic analysis and discourse processing.
- Recent research papers on computational syntax and discourse, identifying strengths and weaknesses.
- Develop and implement sophisticated algorithms for parsing syntactic structures and analyzing discourse coherence

Course Outline: Introduction to Computational Syntax and Discourse, Formal Grammars and Parsing Techniques, Statistical and Neural Models, Discourse Coherence and Cohesion, Cross-Linguistic Syntactic Analysis, Advanced Parsing Techniques, Integration of Syntax and Discourse, Applications and Case Studies, Ethical Considerations and Future Directions.

Reference Material:

1. Manning, Christopher D., and Hinrich Schütze. Foundations of Statistical Natural Language Processing, 1st Edition., MIT Press, 1999.
2. Jurafsky, Daniel, and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 3rd Edition., Pearson, 2023.
3. Collins, Michael. Head-Driven Statistical Models for Natural Language Parsing, Ph.D. Dissertation, University of Pennsylvania, 1999.
4. Daumé III, Hal. A Course in Machine Learning, 2nd Edition., Self-published, 2016.

Course Name:	Advanced Natural Language Engineering
Course Code:	CS802
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This advanced course delves into sophisticated techniques and methodologies in natural language engineering. It focuses on cutting-edge approaches for developing and optimizing natural language processing systems, including deep learning methods, advanced linguistic modeling, and innovative applications. Students will engage with the latest research, algorithms, and tools to tackle complex problems in natural language understanding and generation.

Course Objectives: Introduction to Advanced Natural Language Engineering, Deep Learning for NLP, Transformer Models and Attention Mechanisms, Language Generation and Text Summarization, Sentiment Analysis and Emotion Detection, Advanced Syntax and Semantics, Knowledge Graphs and Semantic Networks, Multimodal NLP and Cross-Modal Applications, Evaluation Metrics and Benchmarking, Emerging Trends and Research Directions.

Course Outline:

- Master advanced techniques in natural language engineering, including deep learning and complex linguistic modeling.
- Design and implement state-of-the-art NLP systems for various applications syntax and discourse, identifying strengths and weaknesses.
- Conduct original research contributing to advancements in the field of natural language processing.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Goldberg, Yoav. Neural Network Methods for Natural Language Processing, 1st Edition., Morgan & Claypool Publishers, 2017.
2. Peters, Matthew E., et al. Deep Contextualized Word Representations, 1st Edition., Association for Computational Linguistics, 2018.
3. Vaswani, Ashish, et al. Attention Is All You Need, 1st Edition., Neural Information Processing Systems, 2017.
4. Jurafsky, Daniel, and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 3rd Edition., Pearson, 2023.

Course Name:	**Neural Machine Translation**
Course Code:	CS803
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This advanced course delves into the principles and methodologies of Neural Machine Translation (NMT). It covers the latest deep learning techniques and architectures used in NMT, including sequence-to-sequence models, attention mechanisms, and transformer-

based approaches. Students will explore both theoretical aspects and practical implementations, gaining a comprehensive understanding of how neural networks are applied to translation tasks.

Course Objectives

- Understand and apply neural network architectures for machine translation, including sequence-to-sequence and transformer models.
- Evaluate and compare the performance of different NMT models using appropriate metrics and benchmarks.
- Analyze recent research in neural machine translation to identify trends, challenges, and innovations.

Course Outline: Introduction to Neural Machine Translation, Sequence-to-Sequence Models, Attention Mechanisms and Self-Attention, Transformer Architectures, Pre-trained Language Models (e.g., BERT, GPT), Multilingual and Zero-Shot Translation, Model Training and Optimization, Evaluation Metrics and Techniques, Case Studies and Applications, Recent Advances and Research Directions.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Vaswani, Ashish, et al. Attention Is All You Need, 1st Edition., Neural Information Processing Systems, 2017.
2. Goldberg, Yoav. Neural Network Methods for Natural Language Processing, 1st Edition., Morgan & Claypool Publishers, 2017.
3. Jurafsky, Daniel, and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 3rd Edition., Pearson, 2023.
4. Zhang, Yao, and Joakim Nivre. Deep Learning for Natural Language Processing: Theory and Practice, 1st Edition., Springer, 2020

Course Name:	**Advanced Wireless Sensor Networks**
Course Code:	CS804
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course provides a comprehensive study of sensor technologies, wireless sensor networks (WSN), and wireless body area networks (WBAN), focusing on their design, implementation, and application. Students will explore the integration of these networks in various domains, including healthcare, environmental monitoring, and smart cities.

Course Objectives: By the end of the course, students should be able to:

- Design and implement wireless sensor networks and wireless body area networks.

- Address challenges related to energy efficiency, security, and privacy in sensor networks.
- Integrate sensor networks into larger IoT systems and analyze their applications.
- Conduct research and development in advanced sensor network technologies.

Course Outline: Introduction to Sensors and Sensor Networks: Overview of sensor types and characteristics. Introduction to sensor network architecture and components.
Wireless Sensor Networks (WSN): Fundamentals of WSN design and operation. Communication protocols and data aggregation techniques.
Wireless Body Area Networks (WBAN): Architecture and protocols specific to WBAN. Applications in healthcare and medical monitoring.
Sensor Data Acquisition and Processing: Techniques for data collection and processing in sensor networks. Data fusion and decision-making in WSN and WBAN.
Energy Efficiency and Power Management: Strategies for energy-efficient sensor network design. Power management techniques and energy harvesting.
Security and Privacy in Sensor Networks: Security challenges and solutions in WSN and WBAN. Privacy-preserving techniques and protocols.
Integration with IoT: Role of sensor networks in IoT systems.Case studies of integrated IoT applications.
Applications and Case Studies: Real-world applications in environmental monitoring, healthcare, and smart cities. Analysis of successful sensor network deployments.
Future Trends and Innovations: Emerging trends and technologies in sensor networks. Research directions and opportunities in WSN and WBAN.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Sohraby, Kazem, Daniel Minoli, and Taieb Znati. Wireless Sensor Networks: Technology, Protocols, and Applications. 2nd ed., John Wiley & Sons, 2017. Print. ISBN 978-1-119-24914-4.
2. Gupta, Sandeep K. S., Tridib Mukherjee, and Krishna Kumar Venkatasubramanian. Body Area Networks: Safety, Security, and Sustainability. 1st ed., Springer, 2019. Print. ISBN 978-3-030-03124-5.

Course Name:	**Advanced Network Security**
Course Code:	CS805
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This is a graduate level on Network Security. Students will be expected to read all of the papers assigned during the class or may be added based on class interest. Students will have to write at least two reviews of papers assigned. These will be submitted at the beginning of class. Students submitting reviews for a paper will be expected to be active in the discussion of that paper.

Course Objectives: The objectives of the course are as follows:

- Understand the design and implementation of advanced cryptographic algorithms for wired and wireless computing environments including the design and implementation of RSA and ECC
- Achieve sound knowledge of network security components including the design, implementation, and configuration of Firewalls, Intrusion Detection Systems (static and dynamic checking of programs, anomaly detection, large-scale (Internet-wide) distributed intrusion detection, early sensing, complex attack scenario analysis, and automated response), Prevention Systems, Firewalls, IDSs, VPNs and prevention systems together
- Develop knowledge of advanced network security architectures to allow better network protection, load balancing and recovery from attacks
- Achieve sound knowledge of wireless network security

Course Outline: Security Concepts and Terminology, TCP/IP and OSI Network Security, ITS architecture for security, VANETs security architectures. Access Control Issues (Packet Filters, Firewalls), Communication Security (OSI Layer Security Protocols), Security Tools, Cryptography System Security - Intruders and Viruses, E-mail and Web Security

Reference Material: The following is the recommended list of books (or their latest editions):

1. Stallings, William. Network Security Essentials. 6th ed., Prentice-Hall, 2020. ISBN 978-0-13-518552-6.
2. Maximum Security. 2nd ed., SAMS Books, 2001. ISBN 978-0-672-31890-2.
3. Maximum Linux Security. 2nd ed., SAMS Books, 2001. ISBN 978-0-672-31923-7.
4. Stoll, Clifford. The Cuckoo's Egg: Tracking a Spy Through the Maze of Computer Espionage. Pocket Books, 1990. ISBN 0671726889.
5. Material from the Internet

Course Name:	**Information & Web Semantics**
Course Code:	CS806
Credit Hours:	3
Pre-requisites:	None

Course Introduction: The Semantic Web is concerned with how to characterize web content, web services and web agents to enable greater automation, integration and reuse across applications. This course introduces core topics of the Semantic Web, goes into depth on the technologies underlying it, and considers how the Semantic Web stands to affect everyday life. This course is aimed to give students a detailed understanding of the principles and practices underlying the Semantic Web and to equip them with knowledge engineering skills.

Course Objectives: The objectives if the course are as follows:

- Understand the limitations of the current web in different scenarios
- Know about the enabling technologies of the Semantic Web
- In-depth knowledge of the application of these technologies
- Understand and use the tools developed in the field of web semantics
- Understand how more automation is achieved by adding semantics to web services

Course Outline: Introduction to Semantic Web

The Syntactic Web, The Semantic Web, Working of the Semantic Web, Scope and Boundaries of the Semantic Web, Effects of the Semantic Web on Person, Business, Education and Government

Semantic Web Concepts

Ontologies, Taxonomy, Thesauri and Ontologies, Ontology Classification, Ontology Evolution, Merging, Alignment, Ontology Description Languages, Knowledge Representation in Description Logic, RDF and RDF Schema, OWL, Rule Languages, Semantic Web Services

Semantic Web Technologies

Methods for Ontology Development, Ontology Sources: Dublin Core, vCard, FOAF, Wordnet, CYC, SUMO, Other Ontologies, Ontology Libraries, Semantic Web Software Tools: Ontology Editors, Triple Storage Systems, Reasoners, SW Development Toolkits, Other Tools, SW Projects

Semantic Web Applications

Semantic Desktop: Metadata, Ontologies, Related Applications

Software Agents: Forms, Architecture, Communication in Semantic Web

Other Applications: Art, Geospatial Semantic Web etc

Reference Material: The following is the recommended list of books (or their latest editions):

1. Karin K. Breitman, Morco A. Casanova, and Walter Truszkowski, Semantic Web: Concepts, Technologies, and Applications, Springer-Verlag, 2007.
2. Grigoris Antoniou and Frank van Harmelen, A Semantic Web Primer, MIT Press, 2004.
3. John Davies, Rudi Studer and Paul Warren, Semantic Web Technologies: Trends and Research in Ontology-based Systems, John Wiley & Sons, 2006.
4. Raj Sharman, Rajiv Kishore and Ram Ramesh, ONTOLOGIES: A Handbook of Principles, Concepts and Applications in Information Systems, Springer, 2007.

Course Name:	**Advanced Ontology Engineering**
Course Code:	CS807
Credit Hours:	3
Pre-requisites:	None

In the Computer Science perspective, ontology refers to the specification of knowledge about entities, and their relationships and interactions in a bounded universe of discourse only. As a result, a number of such ontologies have been created in several different areas. This course focuses on Foundations of Ontology-Driven Information Systems (ODIS), Ontology Engineering, ODIS Architectures, and ODIS Applications.

Course Objectives:

- The ability to think about ontologies and information systems in conjunction with each other
- To cover both the structural and temporal dimensions of Information systems
- Know about the principles and techniques of ontology engineering
- Understand ODIS architectures in a variety of contexts including knowledge intensive business process, object models, ontology metaphors,
- Understanding the need of ontologies in Service Oriented Architecture (SOA)

Course Outline: Foundations of Ontology-Driven Information Systems: The road towards ontologies, Use of ontologies in Knowledge Management Systems, Ontologies in Buisness Model reengineering, using Ontologies in Semantic Web

Ontological Engineering**:** Ontological approach to develop knowledge intensive systems, Standards for ontology development, Ontology Specification and Integration, Ontology Revision, Ontology Population

Ontology-Driven Information Systems Architectures:Ontology of Hypermedia Systems, Ontology-enables DBMSs, Ontology-based User Modeling, Ontology-based Personalized Search, Ontology in automating knowledge intensive business processes

Ontology-Driven Information Systems Applications**:** ODIS for Supply chain management, Ontology in News domain, Ontology in Mobile Domain, Ontology in Manufacturing Domain, Ontology in Medical domain, Ontology based smart card system.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Raj Sharman, Rajiv Kishore and Ram Ramesh, Ontologies: A Handbook of Principles, Concepts and Applications in Information Systems, Integrated Series in Information Systems, Springer Science, 2007.
2. Asuncion Gomez-Perez, Oscar Corcho and Mariano Fernandez-Lopez, Ontology Engineering: with examples from the areas of Knowledge Management, e-Commerce and the Semantic Web, Advanced Information and Knowledge Processing Series, Springer 2004.
3. LG Dietz, Enterprise Ontology: Theory and Methodology, Springer 2006.

Course Name:	**Information Visualization and Visual Analytics**

Course Code:	CS808
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This advanced course explores sophisticated techniques and methodologies in information visualization and visual analytics. It focuses on the design, implementation, and evaluation of visualization tools and techniques that facilitate the understanding and analysis of complex data. Students will engage with cutting-edge research, tools, and applications to develop innovative solutions for visualizing and interpreting large-scale and multifaceted data sets.

Course Objectives:

- Design and develop advanced information visualization techniques for complex data sets.
- Evaluate and critique state-of-the-art visualization tools and techniques using appropriate metrics.
- Conduct original research in the field of information visualization and visual analytics.

Course Outline: Introduction to Advanced Information Visualization, Principles of Effective Visualization Design, Visualization Techniques for High-Dimensional Data, Interactive and Dynamic Visualizations, Visual Analytics and Data Exploration, Advanced Visualization for Big Data, Evaluation Methods and User Studies, Integration of Visualization with Machine Learning, Case Studies and Applications, Future Trends and Research Directions.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Few, Stephen. Now You See It: Simple Visualization Techniques for Quantitative Analysis, 2nd Edition., Analytics Press, 2019.
2. Heer, Jeffrey, and Jeffrey Heer. Interactive Data Visualization for the Web, 1st Edition., O'Reilly Media, 2018.
3. Munzner, Tamara. Visualization Analysis and Design, 1st Edition., CRC Press, 2014.
4. Shneiderman, Ben, et al. Designing the User Interface: Strategies for Effective Human-Computer Interaction, 6th Edition., Pearson, 2016.

Course Name:	**Topics in Databases**
Course Code:	CS809
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This advanced course explores sophisticated techniques and methodologies in information visualization and visual analytics. It focuses on the design, implementation, and evaluation of visualization tools and techniques that facilitate the understanding and analysis of complex data. Students will engage with cutting-edge research, tools, and applications to develop innovative solutions for visualizing and interpreting large-scale and multifaceted data sets.

Course Objectives: The objectives of this course are as follows:

- Design and develop advanced information visualization techniques for complex data sets.
- Evaluate and critique state-of-the-art visualization tools and techniques using appropriate metrics.
- Conduct original research in the field of information visualization and visual analytics.

Course Outline: Introduction to Advanced Information Visualization, Principles of Effective Visualization Design, Visualization Techniques for High-Dimensional Data, Interactive and Dynamic Visualizations, Visual Analytics and Data Exploration, Advanced Visualization for Big Data, Evaluation Methods and User Studies, Integration of Visualization with Machine Learning, Case Studies and Applications, Future Trends and Research Directions.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Few, Stephen. Now You See It: Simple Visualization Techniques for Quantitative Analysis, 2nd Edition., Analytics Press, 2019.
2. Heer, Jeffrey, and Jeffrey Heer. Interactive Data Visualization for the Web, 1st Edition., O'Reilly Media, 2018.
3. Munzner, Tamara. Visualization Analysis and Design, 1st Edition., CRC Press, 2014.
4. Shneiderman, Ben, et al. Designing the User Interface: Strategies for Effective Human-Computer Interaction, 6th Edition., Pearson, 2016.

Course Name:	**Special Topics in Computer Science**
Course Code:	CS810
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course for the most cutting edging topics in Computer Science.

Course Objectives: The following are the objectives of the course:

- Understanding the most cutting edge research topics in Computer Science.

Course Outline: Course outline will be decided by the course instructor.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Latest journal and conference papers
2. Books recommended by the instructor.

Course Name:	**Topics in Data Warehousing and Business Intelligence**
Course Code:	CS811
Credit Hours:	3

Pre-requisites: None

Course Introduction: This course provides an insight into data warehousing, its design and architecture, and issues involved in using data warehouse in business organizations. The course also discusses warehouse DBMS, data marts and other advanced techniques including ETL processes.

Course Objectives: The objectives of this course are as follows:

- To discuss issues involved in Data Warehousing.
- To understand the concepts and details of warehouse architecture.
- To understand the working of different data warehouse models and OLAP Operations.

Course Outline: Issues in Data Warehouse Design: monitoring; wrappers; integration; data cleaning; data loading; materialised views; warehouse maintenance; OLAP servers; metadata. Heterogeneous information; the integration problem; the Warehouse Architecture; Data Warehousing; Warehouse DBMS. Aggregations: SQL and aggregations; aggregation functions; grouping. Data Warehouse Models and OLAP Operations: Decision support; Data Marts; OLAP vs OLTP; the Multi-Dimensional data model; Dimensional Modelling; ROLAP vs MOLAP; Star and snowflake schemas; the MOLAP cube; roll-up, slicing, and pivoting. Research topics in Business Intelligence, What is Information Systems and Business Intelligence, Advance Techniques in ETL Process, Introduction to the Unified Dimensional Model (UDM), Dimensions, Cubes and their features, The MDX Language and KPIs.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Fundamentals of Data Warehouses, M. Jarke, M. Lenzerini, Y. Vassiliou, P. Vassiliadis (ed.), Springer-Verlag, 1999.
2. Elizabeth Vitt, Michael Luckevich, Stacia Misner “Business Intelligence: Making Better Decisions Faster” Publisher: Microsoft Press, Publication Date: May 17, 2002, ISBN 0-7356-1627-2
3. Cindi Howson “Successful Business Intelligence: Secrets to Making BI a Killer App” Publisher: The McGraw Hill Companies, Publication Date: November 26, 2007 Edition: 1, ISBN: 978-0-07-149851-7
4. Thomas H. Davenport, Jeanne G. Harris, Robert Morison “Analytics at Work: Smarter Decisions, Better Results” Publisher: Harvard Business School Publishing Corporation Publication Date: February 8, 2010, ISBN 978-1-4221-7769-3
5. Swain Scheps “Business Intelligence for Dummies” Publisher: Wiley Publishing, Inc. Publication Date: January 10, 2008, ISBN 978-0-470-12723-0

Course Name:	**Text Mining**
Course Code:	CS812
Credit Hours:	3

Pre-requisites: None

Course Introduction: This course explores advanced techniques and methodologies for extracting valuable insights from textual data. It provides an in-depth examination of the algorithms, models, and tools used to analyze and interpret large volumes of text. Students will engage with state-of-the-art methods in text processing, feature extraction, and pattern discovery, preparing them to tackle complex text-based challenges in research and industry. The course integrates theoretical foundations with practical applications, emphasizing both the development of new methods and the application of existing ones

Course Objectives:

- Understand advanced text mining techniques for extracting insights from textual data, including text preprocessing, feature extraction, and pattern discovery.
- Develop and implement sophisticated models for text classification, clustering, and topic modeling, leveraging machine learning and statistical methods.
- Evaluate and interpret the effectiveness of text mining algorithms and their applications in various domains.

Course Outline: Introduction to Text Mining, Text Preprocessing and Normalization, Tokenization and Part-of-Speech Tagging, Feature Extraction and Representation, TF-IDF, Word Embeddings, Statistical Models for Text Mining, Text Classification and Supervised Learning, Text Clustering and Unsupervised Learning, Topic Modeling, Sentiment Analysis and Opinion Mining, Named Entity Recognition and Information Extraction, Text Summarization Techniques, Information Retrieval and Search, Evaluation Metrics for Text Mining, Applications in Social Media, Healthcare, and Finance, Ethical Considerations and Challenges in Text Mining.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Feldman, Rajiv, and James Sanger. The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data. Cambridge University Press, 2007.
2. Aggarwal, Charu C., and ChengXiang Zhai. Mining Text Data. Springer, 1st Edition., 2012.
3. Manning, Christopher D., and Hinrich Schütze. Foundations of Statistical Natural Language Processing. MIT Press, 1st Edition., 1999.
4. Jansen, Bernard J., et al. Mining User-Generated Content: An Introduction to Text Mining and Analysis. Springer, 1st Edition., 2011.

Course Name:	**Topics in Data Mining**
Course Code:	CS813
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course is designed in a way to discuss latest issues involved in data mining. The main concept of the course is to discuss latest research dimensions in the field of data mining using latest research papers and literature. The will make an extensive use of online resources.

Course Objectives:

- To review latest research papers in the field of data mining.
- To discover the latest advancements in data mining applications.
- To discuss data mining algorithms**.**

Course Outline: Stream and Sequence Data Mining, Mining Data Streams • Mining Time-Series Data, Time series Analysis, Sequential patterns, Genetic Algorithms, Incremental Mining, Scalability issues of Data Mining Algorithms, Big Data Mining and Analytics**,** Massive Datasets Data Reduction and Normalization • Distributed File Systems • Map-Reduce Patterns and Algorithms • Data Mining applications, Visualization of Data Mining Results, High Performance Computing Applications in Data Mining, Case Studies, Mining the Web (document classification, adaptive documents), Predicting Equity Returns from Securities Data, Decision Support Systems.

Reference Material: The following is the recommended list of books (or their latest editions):

1. J. Han and M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufman, 2000.
2. D. Hand, H. Mannila and P. Smyth. Principles of Data Mining, MIT Press, 2001.
3. M. H. Dunham. Data Mining: Introductory and Advanced Topic. Prentice Hall, 2003.
4. Larry Wasserman ***All of Statistics***: A Concise Course in Statistical Inference. Springer, 2003.
5. The Elements of Statistical Learning, Hastie, Tibshirani, Springer, 01-Dec-2008
6. Pattern Recognition and Machine Learning, Bishop, Springer; 1st ed. 2006

Course Name:	**Topics in Wireless Networks**
Course Code:	CS814
Credit Hours:	3
Pre-requisites:	None

Course Description: Wireless networks are a fast changing field, new technologies and strategies are being introduced rapidly. This course will discuss recent advancements in wireless communication systems. The next generation of wireless communication systems will be discussed, as well as the technologies that power them. Both practical and simplified theoretical aspects will be discussed. Rather than providing in-depth theoretical details, an introduction to the main concepts and an overview of the key points will be provided. The course will cover the following topics:

Course Objectives: The following are the objectives of this course:

- Understand wireless network principles and concepts
- Analyze performance and limitations
- Design and optimize wireless networks for better performance and efficiency
- Assess wireless network security and reliability
- Learn troubleshooting techniques for wireless network issues
- Recognize the role of wireless networks in enabling diverse applications and services
- Stay up-to-date with wireless networking advancements and trends
- Improve problem-solving skills through analytical and critical thinking
- Apply theoretical knowledge to practical scenarios

Course Contents: This course covers the most recent advancements in wireless network technologies, beginning with next-generation wireless networks (5G and 6G), which provide faster speeds, lower latency, and increased connectivity. The most recent Wi-Fi generations, Wi-Fi 6 and 7, offer enhanced performance, capacity, and efficiency. Advanced antenna technologies such as Massive MIMO and Beamforming improve network capacity and performance, while Millimeter Wave Technology allows for high-speed data transfer in 5G networks. Edge computing processes data closer to the user, lowering latency and increasing performance. Network slicing enables customized services and applications by virtualizing wireless networks. Artificial intelligence (AI) and machine learning improve network performance, resource allocation, and security. The course also examines Internet of Things Connectivity, Quantum Computing and Post-Quantum Cryptography for next-generation security, Terahertz Communications for ultra-high-speed data transfer, and Li-Fi for wireless communication via light. Mesh Networking, Software-Defined Radio, and Cognitive Radio also provide dynamic networking, flexibility, and adaptability. Finally, Ultra-Wideband Technology offers high-bandwidth, low-power solutions for accurate location tracking and fast data transfer.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Rappaport, Theodore S. Wireless Communications: Principles and Practice, Feb. 2024.
2. Priyadarshini, S., et al. Mobile and Wireless Communication, Sep. 2023.
3. Rao, K. N. Raja. Advanced Mobile Wireless Communications: A Holistic Coverage from Basic Concepts to 5G Technologies with IoT, Oct. 2023.
4. Bejarano, Oscar. Wireless: A Total Beginner's Guide to Modern Wireless Communication Technologies, Mar. 2023.
5. He, Ruisi, and Bo Ai. Wireless Channel Measurement and Modeling in Mobile Communication Scenario: Theory and Application, Feb. 2024.
6. Cooklev, Todor, and Andrew E. Yagle. Modern Communications Systems: A First Course, Feb. 2024.
7. Hoang, Dinh Thai, et al. Deep Reinforcement Learning for Wireless Communications and Networking: Theory, Applications and Implementation, Jun. 2023.

8. Kaushik, Aryan. Integrated Sensing and Communications for Future Wireless Networks: Principles, Advances and Key Enabling Technologies, Dec. 2024.
9. Zhang, Haijun, and Ning Yang. Deep Learning in Wireless Communications, Oct. 2024.

Course Name:	**Topics in Cloud Computing**
Course Code:	CS815
Credit Hours:	3
Pre-requisites:	None

Course Introduction: Cloud computing represents a major paradigm shift in computing from the era of personal computers to the era of computing as a utility. Most major Internet services are already deployed in the "the cloud" to store all our data and execute most applications from the cloud. The primary objective of the course is to provide introduction to the current practices of cloud computing, mainly focusing on cloud computing models, techniques, and architectures.

Course Objectives: When students complete this course, they will:

- Understand the reasons for the paradigm shift
- Have the knowledge of designing and implementing cloud-based software systems
- Be able to understand and work with services of the leading cloud computing providers like Amazon and Google
- Know the current challenges facing cloud computing.
- Be able to pursue research in cloud computing

Course Outline: This course covers the fundamentals of cloud computing, including its definition, characteristics, components, and organizational scenarios. Students will learn about cloud service administration and monitoring, benefits, and limitations, as well as deploying applications over cloud. The comparison of SAAS, PAAS, IAAS cloud computing platforms, Infrastructure as a Service using Amazon EC2, and Platform as Service using Google App Engine, Microsoft Azure, Utility Computing, and Elastic Computing will also be explored.
The basics of virtualization and implementation challenges will be discussed, including system virtualization technologies, such as architectures and internals of KVM, Xen, and VMware. Memory virtualization techniques, ballooning, deduplication, and sharing, as well as network and storage virtualization, will also be covered. Additionally, students will explore virtual machine migration and replication techniques, including pre-copy and post-copy techniques, and their applicability to system availability. NoSQL databases, cloud file systems such as GFS, HDFS, BigTable, HBase, and Dynamo, and Map-Reduce and its extensions will be covered. Enterprise batch processing using Map-Reduce, introduction to cloud development, and example/application of MapReduce will also be explored. The features and comparisons among GFS, HDFS, and other cloud storage solutions will be discussed.

The fundamentals of cloud security, including vulnerability assessment tools for cloud, privacy, and security in cloud, will be covered. Trusted cloud computing, secure execution environments, and communications, as well as identity management and access control, will be explored. Biometric security for cloud, cloud security challenges, virtualization security management, virtual threats, VM security recommendations, and VM-specific security techniques will also be discussed.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Erl, Thomas, and Eric Monroy. Cloud Computing: Concepts, Technology, Security, and Architecture. Pearson, 2023.
2. Comer, Douglas. The Cloud Computing Book: The Future of Computing Explained. 2023.
3. Sehgal, Naresh Kumar, et al. Cloud Computing with Security and Scalability: Concepts and Practices. 2022.
4. Cloud Computing, A Practical Approach, Toby Velte, Anthony Velte, Robert Elsenpeter, McGraw-Hill Osborne Media; 1st edition, 2009.
5. Cloud Application Architectures: Building Applications and Infrastructure in the Cloud, George Reese, O'Reilly Media; 1st edition, 2009.

Course Name:	**Software Reviews and Metrics**
Course Code:	CS816
Credit Hours:	3
Pre-requisites:	None

Course Introduction: Reviews and metrics are essential tools for assessing and guiding software improvements. They help ensure that software meets quality standards, performs well, and aligns with user needs. This course is design to develop skills for improved software development using the techniques of software review and metrics.

Course Objectives: The aim of using reviews and metrics together is to:

- To understand the concept of software measurement and review.
- To use metrics to pinpoint areas needing improvement and conduct reviews to investigate and address specific issues.
- To establish clear objectives based on review findings and metrics, and use them to track progress and measure the impact of improvements.
- To integrate feedback from reviews and metrics into the development process to refine and enhance software continuously.

Course Outline: Reviews: Purpose, process and benefits of Code Reviews, Design Reviews, User Reviews and Feedback, Performance Reviews, Security Reviews. Metrics: Code Quality Metrics,

Performance Metrics, User Experience Metrics:Net Promoter Score (NPS), Customer Satisfaction (CSAT), Defect Metrics, Development Process Metrics, Customer Support Metrics.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Himayat, Saif, and Jameel Ahmad. *Software Understandability Using Software Metrics*. 2023
2. Jones, Capers. A Guide to Selecting Software Measures and Metrics. CRC Press, 2017
3. Löwy, Juval. *Righting Software*. Addison-Wesley Professional, 2019
4. Summers, Boyd L. *Software Engineering Reviews and Audits*. CRC Press, 2011
5. Software Process Improvement: Metrics, Measurements, and Process Mod-
   Elling, Michael Haug, Eric W. Springer, 2001

Course Name:	Advanced Software Architecture
Course Code:	CS817
Credit Hours:	3
Pre-requisites:	None

Course Introduction: To give the students an understanding of the concept of software architecture, and of how this phase in the development between requirement speciation and detailed design plays a central role for the success of a software system. The students will get knowledge of some well-known architecture patterns, and will be able to evaluate architectures for software systems. In addition, the students should get some understanding of how the developers' experiences and the technical and organizational environment will influence on the choice of architecture.

Course Objectives:

- To understand the basics of software architecture.
- To study different types of architectures used in software development industry.

Course Outline: Software architecture terminology, architecture in the system development life cycle, architecture dimensions; physical versus logical architectures, Architectural styles and patterns, methods for constructing and evaluating architectures, and component-based development. Scalable software and SaaS, The Clean Architecture, Latest architecture trends, e.g., Microservices Architecture and Data Flows, Cloud architecture, Architecture integration, Integration Object-oriented frameworks. Web-based architectures, Centralized versus distributed architectures. Literature review.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Fundamentals of Software Architecture. O'Reilly Media, 2020

2. P. Clements, F. Bachmann, L. Bass, D. Garlan, J. Ivers, R. Little, R. Nord, and J. Staord, Documenting Software Architectures: Views and Beyond, Addison Wesley, 2003, ISBN 0-201-70372-6.
3. Taylor, Medvidovic, and Dashofy, Software Architecture: Foundations, Theory, and Practice, 2009
4. Anthony J. Lattanze, Architecting Software Intensive Systems: A Practitioners Guide, 2008, Auerbach Publications
5. Bass, Clements, and Kazman, Software Architecture in Practice (2nd Edition), 2003, Addison-Wesley Professional

Course Name:	**New Trends in Software Engineering**
Course Code:	CS818
Credit Hours:	3
Pre-requisites:	None

Course Introduction: The course provides an overview of the latest developments and research in the field of software engineering. The main objective of this course is to keep the students up to date with the new ideas being presented in flagship software engineering conferences and journals. The entire course will be based upon the literature review of topics from the research papers presented in Software Engineering conferences and published in journals in recent years.

Course Objectives: The objectives of the course are as follows:

- To keep the students up to date with the latest advancements in the field of software engineering.
- To be able to discuss current issues in software engineering research.

Course Outline: Following are some of the proposed topics; the instructor may select any other topic(s) of interest from the latest technologies and may cover two or more of the topics in detail: Advances in Security Software Engineering, Advances in Service Oriented Software Engineering, Agile and Lean development, DevOps and DevSecOps, Open Source Development, Cloud computing, Low code/No-code development, Social and Ethical considerations in Software Development. Literature review and support tools.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Current research publications and literature.
2. Extensive use of online available latest resources

Course Name:	**Context Aware Computing**
Course Code:	CS819
Credit Hours:	3

Pre-requisites: None

Course Introduction: Modern computers are considered away from reality as they are unaware of who, where, and what is around them. This leads to a mismatch between the requirements of an information seeker and the results provided by a computer system. Computers have extremely limited input and are aware of explicit input only. The field of Context-Aware Computing makes computers more aware of the physical and social worlds we live in. Context-awareness is an enabling technology that combines a broad scope of topics in computer science. This course deviates a bit from ubiquitous and pervasive computing and focuses more on context awareness on the web and on mobile platforms which is the current hot area of the field.

Course Objectives: When students complete this course, they will be able to:

- Understand the importance and application of context awareness
- Get an insight into context-aware applications
- Know the methods required in the design of context-aware applications

Course Outline: Context and Context-aware Computing, Context Types, Why Context-aware Computing? Context-aware Applications, Challenges in Implementing a Context-aware Application, Sensing Context, Modeling Context, Context Specification, Context Interpretation, Quality of Context, Context Aware Programming, Programming Models Automatic Adaptivity, Social Information Filtering Web Recommendations, Personalization, User Modeling Location Awareness, GPS, RFIDs and Other Sensors Smartphone and Context Awareness Context-aware Web Services Metadata, Semantics and Context-awareness

Reference Material: The following is the recommended list of books (or their latest editions):

1. Enabling Context-Aware Web Services: Methods, Architectures, and Technologies. Michael Sheng, Jian Yu and Schahram Dustdar. Chapman and Hall/CRC; 1 edition, 2010.
2. Context-aware Semantics-based Information Retrieval, C. Kessler. IOS Press, 2010.
3. Context-Aware Pervasive Systems: Architectures for a New Breed of Applications , Seng Loke. Auerbach Publications; 1 edition, 2006.
4. Context-Aware Mobile and Ubiquitous Computing for Enhanced Usability: Adaptive Technologies and Applications, Dragan Stojanovic. Information Science Reference; 1 edition, 2009.
5. Quality of Context: First International Workshop, QuaCon 2009, Stuttgart, Germany, June 25-26, 2009. Revised Papers (LNCS), Kurt Rothermel, Dieter Fritsch, Wolfgang Blochinger, Frank Dürr. Springer, 2009.
6. Location- and Context-Awareness: First International Workshop, LoCA 2005, Oberpfaffenhofen, Germany, May 12-13, 2005, Proceedings (LNCS), Thomas Strang, Claudia Linnhoff-Popien. Springer, 2005.

Course Name:	Topics in Digital Forensics
Course Code:	CS820
Credit Hours:	3
Pre-requisites:	None

Course Introduction: The vast majority of modern criminal investigations involve some element of digital evidence, from mobile phones, computers, CCTV and other devices. This course will cover fundamentals of computer forensics and investigations. It will focus on the technological aspect of digital forensics with less regard to its legal aspect. This course provides a thorough explanation of how computers & networks function, how they can be involved in crimes, and how they can be used as evidence. It covers how to conduct digital investigations and how to locate and utilize digital evidence on computers, networks, and mobile systems. Topics include a systematic approach to computer investigations, email and image file analysis; and guidelines for investigation reporting and development of a computer forensics laboratory. Various forensic tools will be used, preferably open source.

Course Objectives: Upon completion of this course, a student will be able to

- Utilize a systematic approach to computer investigations
- Utilize various forensic tools to collect digital evidence
- Perform digital forensics analysis upon Windows, MAC and LINUX operating systems
- Perform digital forensics analysis upon Mobile systems and Smart phones
- Perform email investigations
- Analyze file systems
- Understand anti-forensic methods and tools

Course Outline: Computer Investigations Case examination and assessment, Evidence gathering, Systematic approaches to computer investigations, Conducting an investigation
Operating Systems and File Systems Review of file structures, boot processes, and data structures of popular operating systems, NTFS, Macintosh, Linux Preparing Media to Accept an Image Create a partition, Wipe partition using DOD standard, Verify wipe of partition Digital Forensics Evidence Restoring a Hard Disk Image, Verifying restore was successful, Boot to the evidence Operating System Data Acquisition Identify methods, Utilization of various data acquisition tools Computer Forensic Analysis Concepts, Utilization of various analysis tools, Recognizing, locating, recovering and analyzing images, Processing evidence with FTK, Data Carving, Searching the Registry Linux Forensics Linux Distributions Boot block, superblock, inode block and data block, Understanding inodes, Linux Loader & GRUB, Linux drives and partition schemes, Sleuth Kit, Autopsy, HELIX and, KNoppix MAC Forensics HFS, HFS+, Finder, File Manager, Macintosh acquisition methods using MacQuisition, Using Black Bag Tools. Computer Forensic Investigation Reporting Reporting guidelines, Witness Requirements, Anti Forensics.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Altheide, Cory, Harlan Carvey. Digital Forensics with Open Source Tools. Syngress Elsevier, 2011. ISBN 978-1-59749-588-1.
2. Volonino, Linda, Reynaldo Anzaldua. Computer Forensics For Dummies. For Dummies, 2008. ISBN 978-0-470-16595-6.
3. Nelson, Bill, Amelia Phillips, Christopher Steuart, Michael Thomson. Guide to Computer Forensics and Investigations. 3rd ed., Thomson, 2004. ISBN 0-619-21706-5.
4. Buchanan, William. Introduction to Security and Network Forensics. Auerbach Publications, 2011. ISBN 978-1-4200-9134-5.
5. Volonino, Linda, Robert Robinson. Principles and Practice of Information Security. Prentice Hall, 2003. ISBN 0-13-184027-4.
6. Casey, Eoghan. Handbook of Digital Forensics and Investigation. Academic Press, 2009. ISBN 978-0-12-374267-4.
7. Casey, Eoghan. Digital Evidence and Computer Crime: Forensic Science, Computers, and the Internet. 3rd ed., Academic Press, 2011. ISBN 978-0-12-374267-4.

Course Name:	**Social Web**
Course Code:	CS821
Credit Hours:	3
Pre-requisites:	None

Course Introduction: From Twitter to Facebook and all the way back to email, social computing is one of the biggest forces on the Internet. The course is about understanding key issues around social web, a field of study concerning with using computing techniques and artifacts to support, mediate, and understand aspects of social behaviors and social interactions. Today, numerous instances and models of social web are prevalent among end-users, such as Wikipedia, social networking sites (e.g. Facebook), micro blogging (e.g., Twitter), photo sharing (e.g. Flickr), instant messaging (e.g. MSN) and so on. The flourishing of social web raises the needs to obtain deeper understanding about how these technologies influence human behaviors, and to figure out how to improve existing designs and devise new models based on the understanding of human behaviors in technological contexts. It is the state-of-the-art of social web research and practice to take both technical and human factors into consideration, and perform analyses and design at the level of "socio-technical systems", which are abstract systems consisting of both technical components (e.g., the software layer of Facebook) and people interacting with one another over the mediation of technologies (e.g. users of Facebook). This course will guide students to take a close look at some prominent ways that this approach functions in the world today, and to understand certain principles and techniques of social web.

Course Objectives: When students complete this course, they will be able to:

- Understand important features of social web.
- Design and prototype new social computing systems.
- Analyze data left behind in social media.
- Understand the research issues in this field.
- Understand the range of social web applications and concepts.
- Understand and apply concepts of computational models underlying social web.
- Carry out simple forms of social analytics, involving network and language models, applying existing analytic tools on social information.
- Design and launch social web applications.
- Understand the broad aspects of, and implement, richer social web models in social computing applications.
- Evaluate emerging social web applications, concepts, and techniques in terms of key principles.

Course Outline: Social Web Evolution and State-of-the-Art, Social Relationships, Social Network Analysis, Mobility and Social Context, Human Computation, Crowd-sourcing, Incentive Mechanisms, Markets and Prediction Markets, Gamification, Computational Models, Organizations, Social Norms, Argumentation, Social Informatics, Emergence, Social Computing in the Large, Social Interpretation of Information, Socio-technical Systems, Security, Common Threads, Open Problems, Status and Trends, Distributed Collaboration and Online Communities, Sharing Content, Trading and Playing, Discussions and Socialization, Blogs and Wikis, Wikipedia Social Networking, Dealing with Free Riding and Malicious Behavior, Search Engine Optimization, Business Models for Social Media, Secure Social Networks, Web Services, Cloud Computing and Peer-2-Peer Systems, Multi-Agent Systems, Streaming Systems.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Tsvetovat, Maksim, and Alexander Kouznetsov. Social Network Analysis for Startups: Finding Connections on the Social Web. O'Reilly Media, Inc., 2011. Print. ISBN 978-1-4493-0947-5.
2. van Steen, Maarten. Graph Theory and Complex Networks: An Introduction. Paperback ed., Routledge, 2010. Print. ISBN 978-1-4398-1818-0.
3. Dasgupta, Subhasish, ed. Social Computing: Concepts, Methodologies, Tools, and Applications. IGI Global, 2009. Print. ISBN 978-1-60566-984-7.
4. Papadopoulou, Panagiota, ed. Social Computing Theory and Practice: Interdisciplinary Approaches. IGI Global, 2010. Print. ISBN 978-1-60566-984-7.

Course Name:	**New Trends in Wireless Sensor Networks**
Course Code:	CS822
Credit Hours:	3
Pre-requisites:	None

Course Introduction: his course aims introducing concepts and research topics in Wireless Sensor Network. It will cover topics ranging from Introduction to Sensor networks and its applications, Security issues in WSN, MAC protocols in WSN, Sensor Database System, Localization and Topology management and the methods that are used in Localization.
Further new research topics may also be included in the course depending on new research made in the field of Wireless Sensor Networks. Each discussion-oriented lecture will be preceded by the reading of 1-2 papers, resulting in a rich collection of papers by the end of the semester.

Course Objectives:

- To introduce current research topics otherwise not covered in other courses.
- To introduce new areas of research related to Wireless Sensor Network.

Course Outline: Introduction will include Wireless Sensor Networks, Typical Architecture, Characteristics of WSN, Applications of WSN, and Challenges in WSN. New issues related to Security, Sensor Database System, Localization and Management. In addition any other current topic deemed necessary by the instructor may also be included.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Akyildiz, Ian F., and Mehmet Can Vuran. Wireless Sensor Networks. 1st ed., Wiley, 2010. Print. ISBN 978-0-470-03601-3.
2. Wireless Sensor Networks,, www.scrip.org/journal/wsn.
3. Ad Hoc Networks ISSN: 1570-8705, ELSEVIER
4. Extensive use of latest available online research material.

Course Name:	**Topics in Embedded Systems**
Course Code:	CS823
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course provides an in-depth exploration of advanced topics in embedded systems, covering cutting-edge research areas, design methodologies, and future directions. Students will engage with contemporary challenges and innovations, preparing them to contribute to the field through original research.
Course Objectives: By the end of the course, students should be able to:

- Critically analyze advanced topics and trends in embedded systems.
- Conduct independent research and contribute to the field through original work.
- Design and evaluate complex embedded systems for various applications.
- Address security, reliability, and performance challenges in embedded systems.

Course Outline: Introduction to Advanced Embedded Systems:

- Overview of embedded systems architecture and design principles.
- Current trends and challenges in the field.

System Design and Architecture:

Advanced topics in system-on-chip (SoC) and microcontroller design.

Hardware/software co-design methodologies.

Real-Time and Distributed Systems:

Design and analysis of real-time embedded systems.

Distributed embedded systems and networked control systems.

Embedded Systems in IoT:

Role of embedded systems in IoT applications.

Design considerations for IoT devices and networks.

Security and Privacy:

Security threats and vulnerabilities in embedded systems.

Techniques for secure embedded system design.

Low-Power and Energy-Efficient Design:

Techniques for low-power embedded system design.

Energy harvesting and power management strategies.

Machine Learning and Embedded AI:

Integration of AI and machine learning in embedded systems.

Applications of embedded AI in various domains.

Research Methodologies and Tools:

Advanced research methodologies in embedded systems.

Tools and frameworks for embedded system development and analysis.

Emerging Trends and Future Directions:

Exploration of future trends and technologies in embedded systems.

Development of research proposals and projects.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Vahid, Frank, and Tony Givargis. Embedded System Design: A Unified Hardware/Software Introduction. 1st ed., Wiley, 2002. Print. ISBN 978-0-471-22444-7.
2. Kopetz, Hermann. Real-Time Systems: Design Principles for Distributed Embedded Applications. 2nd ed., Springer, 2011. Print. ISBN 978-1-4419-8236-0.

Course Name:	**Advanced Middleware for Wireless Sensor Networks and Distributed Systems**
Course Code:	CS824
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course provides a comprehensive study of sensor technologies, wireless sensor networks (WSN), and wireless body area networks (WBAN), focusing on their

design, implementation, and application. Students will explore the integration of these networks in various domains, including healthcare, environmental monitoring, and smart cities.

Course Objectives: By the end of the course, students should be able to:

- Design and implement wireless sensor networks and wireless body area networks.
- Address challenges related to energy efficiency, security, and privacy in sensor networks.
- Integrate sensor networks into larger IoT systems and analyze their applications.
- Conduct research and development in advanced sensor network technologies.

Course Outline: Introduction to Sensors and Sensor Networks:

Overview of sensor types and characteristics.
Introduction to sensor network architecture and components.

Wireless Sensor Networks (WSN):

Fundamentals of WSN design and operation.
Communication protocols and data aggregation techniques.

Wireless Body Area Networks (WBAN):

Architecture and protocols specific to WBAN.
Applications in healthcare and medical monitoring.

Sensor Data Acquisition and Processing:

Techniques for data collection and processing in sensor networks.
Data fusion and decision-making in WSN and WBAN.

Energy Efficiency and Power Management:

Strategies for energy-efficient sensor network design.
Power management techniques and energy harvesting.

Security and Privacy in Sensor Networks:

Security challenges and solutions in WSN and WBAN.
Privacy-preserving techniques and protocols.

Integration with IoT:

Role of sensor networks in IoT systems.
Case studies of integrated IoT applications.

Applications and Case Studies:

Real-world applications in environmental monitoring, healthcare, and smart cities.
Analysis of successful sensor network deployments.

Future Trends and Innovations:

Emerging trends and technologies in sensor networks.
Research directions and opportunities in WSN and WBAN.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Sohraby, Kazem, Daniel Minoli, and Taieb Znati. *Wireless Sensor Networks: Technology, Protocols, and Applications*. Wiley-Interscience, 2007.

2. Gupta, Sandeep K. S., Tridib Mukherjee, and Krishna Kumar Venkatasubramanian. *Body Area Networks: Safety, Security, and Sustainability*. Cambridge University Press, 2013.

Course Name:	**Topics in Information Security**
Course Code:	CS825
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course covers both computational and information-theoretic security approaches, as well as their combined use in cryptography. The course also covers the application of information security technology to real life problems, including selected computer and network security topics. Critical information society services, such as electronic voting, secure identification and privacy protection, will be used as case studies.

Course Objectives: The objectives of this course are as follows:

- Familiarity with scientific challenges in information security.
- Ability to extract information from scientific papers in the area.
- Comfortability with security proofs and ability to think abstractly about information security problems.
- Increased sensibility to privacy issues, anonymity requirements and related protection/anonymisation techniques.

Course Outline: Foundations of cryptography, Applications of computational number theory to cryptography, Information theoretic security and quantum cryptography, Elliptic curve cryptography, Privacy and anonymity concerns and solutions etc.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Tipton, Harold F., and Micki Krause, editors. *Information Security Management Handbook*. 5th ed., Auerbach Publications, 2004.
2. Bishop, Matt. Computer Security: Art and Science. 2nd ed., Addison-Wesley, 2018.
3. Extensive use of latest online resource

Course Name:	**Topics in Real-Time Systems**
Course Code:	CS826
Credit Hours:	3
Pre-requisites:	None

Course Introduction: The course discusses the advanced topics and issues in Real-Time systems which will help students understand the problems and issues with Real-Time Systems.

Course Objectives: The objective of this course is to give a detailed account of all the issues in Real Time Systems. After the course students should:

- Understand the different concepts of real-time systems
- Be able to identify problems and conduct research in the area of real-time systems.

Course Outline: Review of the basics of Real Time Systems, concurrency in Real-Time Systems, scheduling on single processors and multiprocessors: Fixed and dynamic priority systems, shared Resources: on single and multiprocessors, Schedulability Analysis, Reliability and Fault Tolerance, Support for Real Time in different Operating Systems.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Burns, Alan, and Andy Wellings. Real-Time Systems and Programming Languages: ADA 95, Real-Time Java, and Real-Time POSIX. 4th ed., Addison-Wesley Longman Publishing Co., Inc., 2009. Print. ISBN 978-0-321-41745-9.
2. Buttazzo, Giorgio, Giuseppe Lipari, Luca Abeni, and Marco Caccamo. Soft Real-Time Systems: Predictability vs. Efficiency. Plenum Publishing Co., 2005. Print. ISBN 978-0-306-48482-7.
3. Buttazzo, Giorgio. Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications. Springer, 2011. Print. ISBN 978-1-4614-0675-4.

Course Name:	**Real-Time Scheduling Theory**
Course Code:	CS827
Credit Hours:	3
Pre-requisites:	None

Course Introduction: In this course, scheduling theories will be studied to provide formal design and verification of real-time systems.

Course Objectives: The main objectives are to introduce the basic concepts of real-time scheduling, illustrate the most significant and state-of-the-art results in the field, and provides the basic methodologies for designing predictable computing systems which can be used to support critical control applications. Students will be able to understand the real-time scheduling issues on single and multiprocessor systems.

Course Outline: Introduction to Task Models and Scheduling, Uniprocessor Scheduling for Periodic/Sporadic Tasks, Resource Sharing and Priority Inversion, Resource Reservation Servers, Worst-Case Execution Time Analysis, Multiprocessor Scheduling, Schedulability with Resource-Sharing for Multiprocessor.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Burns, Alan, and Andy Wellings. Real-Time Systems and Programming Languages: ADA 95, Real-Time Java, and Real-Time POSIX. 4th ed., Addison-Wesley Longman Publishing Co., Inc., 2009. Print. ISBN 978-0-321-41745-9.
2. Buttazzo, Giorgio, et al. Soft Real-Time Systems: Predictability vs. Efficiency. Plenum Publishing Co., 2005. Print. ISBN 978-0-306-48482-7.
3. Buttazzo, Giorgio. Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications. Springer, 2011. Print. ISBN 978-1-4614-0675-4.
4. Davis, Robert I., and Alan Burns. "A Survey of Hard Real-Time Scheduling for Multiprocessor Systems." ACM Computing Surveys, vol. 43, no. 4, 2011, pp. 35:1-35:44. Print. DOI: 10.1145/1978802.1978812.
5. Zhang, Lixiang, et al. "Distributed Real-Time Scheduling in Cloud Manufacturing by Deep Reinforcement Learning." IEEE Transactions on Industrial Informatics, vol. 18, no. 12, 2022, pp. 8999-9007. Print. DOI: 10.1109/TII.2022.3180459.

Course Name:	**Sustainable Software Engineering**
Course Code:	CS828
Credit Hours:	3
Pre-requisites:	None

Course Introduction: Green software engineering is an emerging research field which aims at creating, using, and disposing the energy-efficient software in an environment friendly manner with less negative impacts. The research community strongly believes that the energy efficiency and sustainability of the software can be improved by modifying the existing software engineering methods. This course will familiarize the scholars to identifies and map such methods for green and sustainable software development.

Course Objectives: After completing this course the students should be able to:

- Identify the research types, research goals, software engineering research topics, accepted validation methods and publication that are used in the field of green and sustainable software engineering.
- Summarize the body of knowledge in the field of green and sustainable software engineering and provides a platform to conduct future research.

Course Outline: Sustainable development goals (SDGs) and role of software, Concepts of Green and sustainable software, Introduction to sustainability in in Software Engineering, Environments, processes and construction which include Green Software Engineering Environments, Processes for sustainable and Sustainable Software Engineering, Constructing Green Software Services: From Service Models to Cloud-Based Architecture, Sustainability: Sustainability dimensions, Sustainable software development process, Economic Aspects of Green and sustainable ICT, Green Software Quality Factors, From Requirements Engineering to Green Requirements

Engineering, Towards Green Software Testing, Green Software, Green Software and Software Quality, Open Innovation for Sustainable Software

Reference Material: The following is the recommended list of books (or their latest editions):

1. Calero, Coral, et al. Software Sustainability. Springer Nature, 2021. Print. ISBN 978-3-030-65692-4.
2. Gupta, Varun, et al. Sustainability in Software Engineering and Business Information Management. Springer Nature, 2023. Print. ISBN 978-3-031-25643-8.
3. Calero, Coral. Green in Software Engineering. Springer International Publishing, 2016. Online. DOI: 10.1007/978-3-319-39548-8.
4. Online research material

Course Name:	**Enterprise Architecture and Integration**
Course Code:	CS829
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course will build upon the ICT knowledge by developing skills in enterprise architecture planning (EAP) and in enterprise application integration (EAI). Using EAP, to create architectures that define and describe the data, applications, and technology needed to support organizations. EAI, will provide experience in creating strategic business solutions using Web services and middleware to integrate the functionality of an organization's existing applications, commercial packaged applications, and new code.

Course Objectives: To introduce:

- Enterprise Application Integration (EAI) Technologies and Strategies
- Enterprise and e-Government Portals for Integrated Access to Enterprise Resources
- Web Services and Service-Oriented Architecture (SOA) Business Process Management (BPM) Concepts for Real-Time Enterprise Integration
- Evolving Enterprise Integration Strategies to Enterprise Architecture

Course Outline: Introduction to Enterprise Architecture, Definition and Purpose, Key Frameworks, TOGAF (The Open Group Architecture Framework), Zachman Framework), EA Components, Methodologies. TOGAF: Detailed exploration of TOGAF and Zachman Framework. Business Process Modeling, Information Architecture, Data Modeling, Information Governance, Application Architecture, Application Integration Patterns, such as service-oriented architecture (SOA) and microservices, API Management, Technology Architecture, Infrastructure Design, Cloud Computing Overview of cloud architecture, Integration Techniques and Tools, Integration

Patterns, Middleware, Governance and Management, EA Governance, Digital Transformation concepts.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Minoli, Daniel. Enterprise Architecture A to Z. Auerbach Publications, 2016. Print. ISBN 978-1-4665-9493-4.
2. Hazra, Tushar K., and Bhuvan Unhelkar. Enterprise Architecture for Digital Business. CRC Press, 2020. Print. ISBN 978-0-367-14455-6.
3. Finkelstein, Clive. Enterprise Architecture for Integration. 1st ed., Artech House, 2006. Print. ISBN 978-1-58053-889-6.
4. Online research material.

Course Name:	**Topics in High Performance Computing**
Course Code:	CS830
Credit Hours:	3
Pre-requisites:	None

Course Introduction: The course will study high performance computer architectures, including modern parallel processors, and will describe how an algorithm interacts with these architectures. It will also look at practical methods of estimating and measuring algorithm/architecture performance.

Course Objectives: Students completing this course should be able to understand the cutting-edge issues and problems in high-performance and scientific computing.

Course Outline: Algorithmic models (the view from Berkeley); Computational models (Flynn's taxonomy); Communication models (interconnects, message passing); Memory models (NUMA etc); Single-computer technologies (vector/SIMD computing via AVX/SSE, multi-core computing via OpenMP, many-core computing via OpenCL); Multi-computer technologies (cluster computing via MPI); Other approaches (cloud, distributed and redundant file systems, load balancing, check-pointing); Design and implementation of parallel algorithms and libraries. Scientific computing using GPUs. Performance issues in machine learning and deep learning model training.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Shalf, John. "The Future of Computing Beyond Moore's Law." Philosophical Transactions of the Royal Society A, vol. 378, no. 2166, 2020, pp. 20190061. Online. DOI: 10.1098/rsta.2019.0061.
2. Ashari, Ahmad, and Mardhani Riasetiawan. "High Performance Computing on Cluster and Multicore Architecture." TELKOMNIKA (Telecommunication Computing Electronics and Control), vol. 13, no. 4, 2015, pp. 1408-1413. Online. DOI: 10.12928/telkomnika.v13i4.1413.

3. Eijkhout, Victor, et al. Introduction to High Performance Scientific Computing. Lulu, 2015. Print. ISBN 978-1-312-91767-5.
4. Hager, Georg, and Gerhard Wellein. Introduction to High Performance Computing for Scientists and Engineers. CRC Press, 2010. Print. ISBN 978-1-4200-7315-3.

Course Name:	**Semantic Data Storage and Management**
Course Code:	CS831
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course will enable students to make more informed decisions in an increasingly complex IT environment. It builds a strong understanding of underlying operating systems concepts for storage and prepares you to learn advanced concepts, and technologies.

Course Objectives: When students complete this course, they will be able to semantically enriching operating systems storage mechanisms.

Course Outline: Introduction to Semantic Data Management, Data and Metadata Management, File Systems, Introduction to Distributed Systems, Searching, The Semantic Web Languages, Modeling Web Data Storage, Semantic Web Data Management, Reasoning in the Semantic Web, Semantic Web Data Querying, Ontologies in Practice, Semantic Desktop, Social Semantic Desktops, Desktop Search Engines, Semantic File Systems.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Hartig, Olaf, and Olivier Curé. "Semantic data management in practice." Proceedings of the 26th International Conference on World Wide Web Companion. 2017.
2. Online material

Course Name:	**Topics in User Experience Design**
Course Code:	CS832
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course explores advanced topics in User Experience (UX) Design. It helps students deeply understand the latest trends, ideas, and methods in the field. The course focuses on research-based approaches to designing and evaluating user experiences. Special attention is given to new technologies, sustainable design practices, and global perspectives. Throughout the course, students will conduct research, analyze critically, and work on practical projects. These activities will prepare them to contribute to the most recent and advanced research in UX.

Course Objectives: After completing this course, students should be able to:

- Critically analyze and synthesize contemporary research in User Experience Design.
- Apply advanced UX research methods, both qualitative and quantitative, to investigate user interaction with emerging technologies.
- Design and evaluate innovative user experiences that address global, cultural, and ethical considerations.
- Develop and prototype sustainable UX solutions for diverse applications.

Course Contents: Introduction to Advanced UX Research: Current trends, methodological advances, and key publications in UX. Cognitive and Behavioral UX Research: Cognitive load, mental models, and behavioral science principles in design. Emotion and Experience Design: Measuring emotional responses, affective computing, and emotional UX design. Ethical Considerations in UX Research: Privacy, consent, design justice, and ethical UX practices. Human-AI Interaction and UX: Designing for transparency, explainability, and human-AI collaboration. Accessibility in UX Design: Principles of accessible design, designing for diverse abilities, and case studies on inclusive interfaces. UX in Healthcare: User-centered design for healthcare applications, patient-centered interfaces, and case studies in medical UX design. Sustainability in UX Design: Sustainable interaction design, green UX, and case studies. Advanced Prototyping and Testing Methods: High-fidelity prototyping, mixed reality, and advanced user testing methodologies. Quantitative UX Research: Statistical methods, big data, UX analytics, and experimental design. Qualitative UX Research: Ethnography, contextual inquiry, and mixed methods approaches. UX for Emerging Technologies: Challenges in VR, AR, IoT, and multi-modal interactions. Global and Cultural Considerations in UX Design: Designing for global audiences, cultural usability, and internationalization. Accessibility (Inclusive Technologies), Ubiquitous Computing, Persuasive Technologies, Social Computing, Wearable Computing, Context-Aware Computing.

Reference Material:

1. Rogers, Yvonne, Helen Sharp, and Jenny Preece. Interaction Design: Beyond Human-Computer Interaction. 6th ed., Wiley & Sons, 2023
2. Lazar, Jonathan. Research Methods in Human-Computer Interaction. 2nd ed., Wiley, 2017.
3. Latest journal papers will be provided in class for study.

Course Name:	**Soft Computing**
Course Code:	CS833
Credit Hours:	3
Pre-requisites:	None

Course Introduction: Soft Computing refers to a collection of computational techniques in computer science, artificial intelligence and engineering disciplines which attempt to study, model and analyze complex problems - those for which more conventional methods have not yielded low cost, analytic and complete solutions. Unlike conventional computing, soft computing techniques are tolerant of imprecision, uncertainty and approximations.

Course Objectives: The objective of the course is to design and develop intelligent systems in the framework of soft computing, and apply to some general and scientific application-driven environments. Students who successfully complete this course will be able to:

- Have a general understanding of soft computing methodologies, including artificial neural networks, fuzzy sets, fuzzy logic, fuzzy clustering techniques and genetic algorithms.
- Study neuro-fuzzy control and inference systems.
- Have an insight into the genetic algorithms and computing, one of the powerful techniques to tackle hard optimization problems.
- Design and development of certain scientific and commercial application using computational neural network models, fuzzy models, fuzzy clustering applications and genetic algorithms in specified applications.
- Study all these techniques from the point of view of the WWW.

Course Outline: Introduction, Tools, Fuzzy Reasoning, Fuzzy Inference, Genetic Algorithms and its Applications, Fuzzy Logic, Applications, Neural Networks and its Applications, Learning (Supervised/Unsupervised, etc), Clustering and Classification, Case-based Reasoning and its Applications, Hybrid Systems, Adaptivity, Techniques Usages, Knowledge Management.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Pratihar, Dilip Kumar. Soft Computing: Fundamentals and Applications. Alpha Science International, Ltd., 2013. Print. ISBN 978-1-84265-741-5.
2. Ma, Zongmin, ed. Soft Computing in Ontologies and Semantic Web. Vol. 204, Springer Science & Business Media, 2007. Print. ISBN 978-3-540-37336-6.
3. Harwood, Chris J. Soft Computing and Intelligent Systems: Theory and Applications. Kybernetes, 2013. Print. ISSN 0368-492X.
4. Tiwari, Ashutosh, et al., eds. Applications of Soft Computing: Recent Trends. Springer Science & Business Media, 2010. Print. ISBN 978-1-84996-077-8.

Course Name:	**Biomedical Image Processing**
Course Code:	CS834
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course on Biomedical Image Processing delves into the techniques and methodologies used to analyze and interpret medical and biological images. The course emphasizes both traditional image processing techniques and modern computational methods, including machine learning and artificial intelligence. Students will learn to address complex challenges in the analysis of medical imaging modalities such as MRI, CT, and microscopy, with applications ranging from diagnostics to treatment planning and research.

Course Objectives:

- Understand advanced image processing techniques tailored for biomedical applications.
- Develop and implement algorithms for image enhancement, segmentation, and feature extraction in medical and biological images.
- Conduct research in biomedical image processing, demonstrating expertise in data analysis, algorithm development, and application to real-world problems.

Course Outline: Introduction to Biomedical Image Processing, Image Acquisition and Preprocessing, Image Enhancement Techniques, Segmentation Methods (e.g., Thresholding, Region Growing, Active Contours), Feature Extraction and Representation, Registration and Alignment of Biomedical Images, 3D Imaging and Reconstruction, Machine Learning Approaches for Image Analysis, Deep Learning for Medical Imaging, Quantitative Imaging and Radiomics, Integration of Imaging Data with Electronic Health Records, Applications in Diagnostics, Treatment Planning, and Research, Ethical and Privacy Considerations in Biomedical Imaging.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Sonka, Milan, Vaclav Hlavac, and Roger Boyle. Image Processing, Analysis, and Machine Vision. 4th Edition., Cengage Learning, 2014.
2. Santos, James M. Biomedical Image Analysis: A Practical Approach. 1st Edition., CRC Press, 2016.
3. Ourselin, Sébastien, et al. Biomedical Image Analysis: Methods and Applications. 1st Edition., Springer, 2019.
4. Kumar, Anand, et al. Advanced Biomedical Image Analysis: Theoretical and Practical Aspects. 1st Edition., Wiley, 2020.

Course Name:	**Topics in Computer Vision**
Course Code:	CS835
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course provides an in-depth exploration of advanced topics and emerging trends in the field of computer vision. The course covers a range of areas from

foundational techniques to cutting-edge research, with an emphasis on both theoretical understanding and practical application. Students will engage with advanced algorithms, models, and methodologies used in modern computer vision tasks, preparing them to conduct innovative research and contribute to advancements in the field.

Course Objectives:

- Understand advanced computer vision techniques to solve complex problems in image and video analysis.
- Design sophisticated algorithms and models for tasks such as object detection, image segmentation, and scene understanding.
- Evaluate the performance of computer vision systems in real-world applications, including accuracy, efficiency, and robustness.

Course Outline: Introduction to Advanced Computer Vision, Deep Learning Techniques for Vision, Object Detection and Localization, Image and Video Segmentation, 3D Vision and Depth Estimation, Scene Understanding and Semantic Segmentation, Optical Flow and Motion Analysis, Generative Models in Vision (e.g., GANs), Vision for Autonomous Systems, Multimodal Vision Systems, Transfer Learning and Domain Adaptation, Vision-Based Robotics, Real-Time Vision Systems, Case Studies and Applications, Ethical Considerations in Computer Vision.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Szeliski, Richard. Computer Vision: Algorithms and Applications. 2nd Edition., Springer, 2022.
2. Bishop, Christopher M. Pattern Recognition and Machine Learning. 1st Edition., Springer, 2006.
3. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep Learning. 1st Edition., MIT Press, 2016.
4. Wang, Xiuqi, et al. Advanced Computer Vision with TensorFlow. 1st Edition., O'Reilly Media, 2021

Course Name:	**Topics in Deep Learning**
Course Code:	CS836
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course provides a comprehensive examination of advanced concepts and recent developments in deep learning. The course explores both foundational theories and state-of-the-art techniques in deep learning, focusing on their application to complex problems across various domains. Students will gain hands-on experience with cutting-edge methods and tools, preparing them to contribute to ongoing research and development in deep learning.

Course Objectives:

- Understand deep learning techniques to complex problems in areas such as image recognition, natural language processing, and reinforcement learning.
- Design sophisticated deep learning models, including neural network architectures, optimization techniques, and regularization methods..
- Evaluate the performance of deep learning models, addressing challenges such as overfitting, computational efficiency, and generalization.

Course Outline: Introduction to Deep Learning, Advanced Neural Network Architectures (e.g., CNNs, RNNs, Transformers), Deep Learning Optimization Techniques, Regularization Methods (e.g., Dropout, Batch Normalization), Transfer Learning and Pretrained Models, Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), Reinforcement Learning and Deep Q-Networks, Attention Mechanisms and Transformers, Neural Architecture Search, Multi-Modal Deep Learning, Scalable Deep Learning and Distributed Training, Applications in Computer Vision, Natural Language Processing, and Robotics, Ethical Considerations and Challenges in Deep Learning.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. *Deep Learning*. 1st Edition., MIT Press, 2016.
2. Bishop, Christopher M. *Pattern Recognition and Machine Learning*. 1st Edition., Springer, 2006.
3. O'Reilly, Tim. *Deep Learning with Python*. 2nd Edition., Manning Publications, 2021.
4. Bengio, Yoshua, Ian Goodfellow, and Aaron Courville. *Deep Learning*. 1st Edition., MIT Press, 2016.

Course Name:	**Advanced Human Computer Interaction**
Course Code:	CS837
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course is designed to provide the student with the core knowledge and skills required for further study and for practical HCI development. This course comprises of emerging issues in the field of Human Computer Interaction and gives students practical and theoretical knowledge in the use of HCI methodologies for both design and evaluation.

Course Objectives: After completing the courses students should be able to:

- Describe the main concepts that influence human-computer interaction
- Explain the main theories of cognition and how these are used when designing interactive systems

- Use the knowledge and skills to conduct further research in the area of Human Computer Interaction.
- Evaluate a design for interacting with a computer system and choose appropriate methods of evaluating an interactive system.
- Demonstrate an understanding of the scope and importance of HCI systems across a range of application domains

Course Outline: Basic Concepts in Human Computer Interaction, Usability paradigm, Usability principles, Interaction paradigms, User Experience and Experience Design, Visualisation, Contextual Design, Usability Evaluation, Evaluation Methods in HCI, Prototyping, Quantitative and Qualitative Evaluation, Interview, Case studies, Focus Groups, Heuristic evaluation, Cognitive walkthrough, Participatory design, Observational methods, Questionnaire design. Accessibility (Inclusive Technologies), Ubiquitous Computing, Persuasive Technologies, Social Computing, Wearable Computing, Context-Aware Computing.

Reference Material: The following is the recommended list of books (or their latest editions):

1 Rogers, Yvonne, Helen Sharp, and Jenny Preece. Interaction Design: Beyond Human-Computer Interaction. 6th ed., Wiley & Sons, 2023. Print. ISBN 978-1-119-76416-8.

2 Lazar, Jonathan. Research Methods in Human-Computer Interaction. 2nd ed., Wiley, 2017. Print. ISBN 978-1-119-34270-7.

3 Shneiderman, Ben. Designing the User Interface. 6th ed., Addison Wesley, 2016. Print. ISBN 978-0-13-438064-3.

4 Cairns, Paul, and Anna Cox, eds. Research Methods for Human-Computer Interaction. Cambridge University Press, 2008. Print. ISBN 978-0-521-86698-2.

5 Jacko, Julie A., ed. Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications. 3rd ed., CRC Press, 2012. Print. ISBN 978-1-4398-2943-1.

Course Name:	**Advanced Learning Technologies**
Course Code:	CS838
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course is designed to introduce research students to a range of themes and research areas in learning technologies.

Course Objectives: After completing the course students should be able to

- Identify learning technologies and tools in order to enhanced different aspects of students' learning experiences
- Understand the core and emerging research areas in the field of technology enhanced learning

- Understand many of the theoretical and pedagogical issues which define digital education
- Design and propose technology based solutions in wide range of learning situations
- Conduct research in a wide range of emerging fields in the area of technology enhanced learning

Course Outline: Foundations of Technology Enhanced Learning, Educational Technology in the context of Millennium Development Goals, Pedagogical uses of digital technology, Open Educational Resources and Practices, Flipped Classrooms, Personal learning Environments (PLE), Learning at Scale, Massive Open Online Courses (MOOCs), Research issues in MOOCs, Open Learning Methodologies, Practices and Platforms, Gamification in Learning Applications, Designing Educational Games, Educational Data Mining and Big Data. Applications in education. Learning Analytics. Mobile Learning Applications. Learning strategies for mobile and ubiquitous learning. Virtual Reality Applications in Learning . Immersive Interfaces for Engagement and Learning, Computer Supported Collaborative Learning. Tools for formative and summative assessment. Cloud Computing in Education. Technology-Enhanced Assessment. Semantic Web technologies to adapt and personalize the learning experience. Social learning techniques. Reviewing empirical evidence of implications of various educational technologies. Review of latest trends in educational technologies.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Erik, Duval. Technology Enhanced Learning: Research Themes. 1st ed., Springer, 2017. Print. ISBN 978-3-319-60651-3.
2. Nick, Rushby. The Wiley Handbook of Learning Technology. 1st ed., Wiley & Sons, 2016. Print. ISBN 978-1-118-92387-8.
3. Beetham, Helen. Rethinking Pedagogy for a Digital Age: Principles and Practices of Design. 3rd ed., Routledge, 2019. Print. ISBN 978-0-8153-6268-4.
4. Further reading material will be provided in the form of essays and research papers from leading journals and conferences in the area of technology enhanced learning

Course Name:	**Serious Games**
Course Code:	CS839
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course examines the role that digital games can play in education as a means to engage students and help them learn a range of topics in a variety of settings. This module introduces students to the field of learning design and Serious Games. The subject introduces the principles of game design, examines research literature surrounding games and learning, and includes reflective participation in gaming culture.

Course Objectives: After completing the course students should be able to

- Demonstrate knowledge and understanding of the key concepts and principles of designing games for learning
- Identify the elements of a serious game
- Have awareness of key research areas in serious games

Course Outline: Introduction to Game Development, Game Design Fundamentals, Introduction to Gamification, Serious Games Design, Level Design, Construction of Choice and Obstacles, Tutorial Systems, Game Challenge Theory and Design, Difficulty vs Punishment and Accessibility vs Contest, Flow (Both Immersive and Adaptive Difficulty), Systems, Dynamics, and Mechanisms, The Mechanics, Dynamics, Aesthetics (MDA) model, Core Game Dynamics, Objectives and Motivation, Game Elements and Atoms, Rule Design, Game Complexity and Difficulty, Game Narrative, Basic principles of non-linear narratives, Interactive narrative and the narrative paradox, Common forms of game narrative and the Heros Journey, Narrative structures for games, Research and Digital Entertainment, Innovative forms of interaction and control, Location aware narrative, Adaptive games, Games development Engines, e.g. Unity. Serious Games Research, Designing Games for Social Change.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Whitton, Nicola. Digital Games and Learning: Research and Theory. Routledge, 2014. Print. ISBN 978-0-415-81635-5.
2. Chou, Yu-kai. Actionable Gamification - Beyond Points, Badges, and Leaderboards. Octalysis Media, 2015. Print. ISBN 978-0-9960269-0-5.
3. Kapp, Karl M. The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. Pfeiffer, 2012. Print. ISBN 978-0-470-64737-3.
4. Whitton, Nicola. Learning with Digital Games: A Practical Guide to Engaging Students in Higher Education. Routledge, 2010. Print. ISBN 978-0-415-49409-4.
5. Zemliansky, Pavel. Design and Implementation of Educational Games: Theoretical and Practical Perspectives. 1st ed., Information Science Reference, 2010. Print. ISBN 978-1-61520-781-4.

Course Name:	**Topics in Cyber Security**
Course Code:	CS840
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course delves into advanced topics in cybersecurity, emphasizing current research, emerging threats, and cutting-edge defense mechanisms. Students will explore sophisticated attack vectors, advanced cryptographic techniques, secure system design, and privacy preservation. Through lectures, research projects, and critical analysis of recent papers, students will gain a thorough understanding of advanced cybersecurity principles and practices.

Course Objectives: The objectives of this course are as follows:

- Analyze and mitigate sophisticated cyber threats and attacks.
- Apply advanced cryptographic techniques to secure systems.
- Conduct and present high-quality research in cybersecurity

.

Course Outline: Advanced Threat Modeling and Attack Vectors, Threat modeling techniques, advanced attack vectors (e.g., APTs, zero-day exploits), and case studies, To understand and model advanced cyber threats and identify potential attack vectors, Advanced Cryptographic Protocols, Zero-knowledge proofs, advanced encryption standards, post-quantum cryptography, and cryptographic protocol verification, Advanced network defense mechanisms, intrusion detection/prevention systems (IDPS), network forensics, and secure communication protocols, Static and dynamic analysis of malware, reverse engineering techniques, and advanced obfuscation methods, Advanced anonymization techniques, privacy-preserving data mining, differential privacy, and secure multi-party computation, IoT security, blockchain security, cloud security, and AI/ML security, Cyber-Physical Systems Security, Security in critical infrastructures, industrial control systems (ICS), and smart grids, Incident Response and Digital Forensics, Advanced incident response strategies, forensic analysis techniques, and legal considerations in cybersecurity, Research Methods and Current Trends in Cybersecurity, Student Research Presentations.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Stallings, William. *Cryptography and Network Security: Principles and Practice*. Pearson, 2017.

2. Katz, Jonathan, and Yehuda Lindell. *Introduction to Modern Cryptography*. 2nd ed., CRC Press, 2014.

Course Name:	**Emerging Trends in Internet of Things**
Course Code:	CS841
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course provides an advanced exploration of the latest trends, challenges, and research opportunities in the Internet of Things (IoT). It covers emerging technologies, innovative applications, and future directions, preparing students to contribute novel insights and advancements to the field.

Course Objectives: By the end of the course, students should be able to:

- Critically analyze emerging trends and technologies in IoT.
- Conduct advanced research and propose innovative solutions.

- Address ethical and privacy issues in IoT development.
- Contribute to the advancement of IoT through original research

Course Outline: Introduction to Emerging IoT Trends:

Overview of current and emerging trends in IoT.

Key drivers and inhibitors of IoT growth.

Advanced IoT Architectures:

Exploration of new architectural models and paradigms.

Edge, fog, and cloud computing in next-generation IoT.

Innovative IoT Protocols and Standards:

Examination of evolving communication protocols.

Impact of standards on IoT interoperability and innovation.

Security and Privacy in IoT:

Advanced security threats and mitigation strategies.

Privacy-preserving technologies and frameworks.

IoT and Artificial Intelligence:

Integration of AI and machine learning in IoT systems.

Intelligent decision-making and autonomous IoT.

IoT in Industry 4.0:

IoT applications in manufacturing and smart factories.

Case studies and real-world implementations.

Ethical Considerations in IoT:

Ethical challenges in IoT research and development.

Frameworks for responsible IoT innovation.

Research Methodologies and Techniques:

Advanced research methodologies in IoT.

Interdisciplinary research approaches and collaboration.

Future Research Directions:

Identifying gaps and opportunities in IoT research.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Buyya, Rajkumar, and Amir Vahid Dastjerdi. *Internet of Things: Principles and Paradigms*. Morgan Kaufmann, 2016.
2. Hersent, Olivier, David Boswarthick, and Omar Elloumi. *The Internet of Things: Key Applications and Protocols*. Wiley, 2012.

Course Name:	**AI-Enabled Wireless and Mobile Networks**
Course Code:	CS842
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course investigates the integration of machine learning techniques into wireless communication systems. This course introduces the fundamental concepts of machine learning and wireless communication before delving into how these two fields interact to solve complex problems in modern communication networks. Students will learn about different machine learning paradigms, such as supervised, unsupervised, and reinforcement learning, as well as how they can be applied in wireless networks. The course includes lectures on machine learning applications at various layers of the communication stack, such as modulation and coding, channel prediction, and resource management. The course also includes guest lectures from industry experts and researchers, who provide insights into the most recent advancements and practical applications of machine learning in wireless communication. Students will be exposed to cutting-edge developments in the field via student presentations and discussions of recent research papers, preparing them for innovation and research in the next generation of wireless networks.

Course Objectives:

- Learn the fundamentals of machine learning and wireless communication systems. Investigate the use of machine learning techniques in various levels of communication
- systems.
- Examine the relationship between signal processing, adaptive filtering, and machine learning.
- Investigate the application of deep learning to complex problems in wireless communication networks.
- Evaluate recent research and developments in machine learning for wireless networks.
- Learn how to use machine learning techniques to solve real-world wireless communication problems.

Course Outline: The course begins with an introduction to machine learning and communication systems, with a focus on how these two fields can be combined to address wireless network challenges. Students will learn about supervised, unsupervised, and reinforcement learning paradigms, as well as how they apply to different aspects of communication systems like modulation classification, adaptive modulation, and coding. The course also looks at the connections between traditional signal processing techniques like Wiener filtering and regression and modern machine learning approaches like deep neural networks.

Students will then investigate the role of unsupervised learning in wireless systems, including the application of principal component analysis in massive MIMO system design and autoencoders in transceiver design. The application of models like the Hidden Markov Model and the Viterbi algorithm. Students will present and discuss recent research papers that use deep learning to address the physical layer of wireless communication. Topics covered include deep learning-based channel decoding, WiFi indoor localization, end-to-end communication system learning, and deep reinforcement learning for dynamic multichannel access. Advanced topics discussed include deep

learning-based MIMO communications and neural network-based feature prediction for wireless channels. Students will gain a thorough understanding of the cutting-edge of applying machine learning to wireless networks as a result of these activities.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Yonina C. Eldar, Andrea Goldsmith, Deniz Gündüz, H. Vincent Poor. Machine Learning and Wireless Communication, New Edition. Cambridge University Press. 2022
2. Hoang, Dinh Thai, Nguyen Van Huynh, et al. Deep Reinforcement Learning for Wireless Communications and Networking: Theory, Applications and Implementation. Willy, 2023.
3. Gopi, E. S., and P. Maheswaran, editors. Proceedings of the International Conference on Machine Learning, Deep Learning and Computational Intelligence for Wireless Communication: MDCWC 2023. Springer, 2024. Signals and Communication Technology.
4. Agrawal, S. K. 5G Wireless Communication System Using Machine Learning (ML). LAP LAMBERT Academic Publishing, 2020.
5. Luo, Fa-Long. Machine Learning for Future Wireless Communications. IEEE Press, 2019.
6. Andreas Lindholm, Niklas Wahlström, Fredrik Lindsten and Thomas B. Schön: Machine Learning, A First Course for Engineers and Scientists. Available online http://smlbook.org/.

Course Name:	**Future Network Technologies**
Course Code:	CS843
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course examines the most recent research trends and innovations in future networks, with a focus on emerging technologies, architectures, and applications. Students will explore cutting-edge topics such as network virtualization, software-defined networking, edge computing, and more.

Course Objectives:

- Learn the fundamental concepts and principles of future networks.
- Analyze and assess emerging technologies and architectures in future networks.
- Investigate and discuss research challenges and opportunities for future networks
- Develop innovative solutions for future network architectures and applications.
- Improve critical thinking and problem-solving abilities in the context of future networks.

Course Outline: The course focusses on network evolution, highlighting the drivers and research challenges that will shape networking's future. Network virtualization and software-defined networking are thoroughly examined, including the concepts, architectures, and management of virtual network functions. The role of SDN controllers and protocols in enabling flexible and

programmable networks is also addressed. The course also delves into edge computing, dew computing, and fog computing, covering the paradigms, architectures, and applications of these emerging technologies. The benefits and challenges of moving computing resources to the network's edge are discussed, as well as the opportunities for innovation and optimization. The course also covers 5G and beyond, including network architecture, emerging technologies, and research directions for the next-generation wireless networks. The vision and roadmap for 6G are also discussed, emphasizing the opportunities for future innovation. Quantum networking and post-quantum cryptography are introduced, covering the fundamentals of quantum computing and networking, quantum key distribution, and the implications for future network security. The importance of post-quantum cryptography and the current state of research in this field are also discussed.The role of artificial intelligence and machine learning in networking is investigated, including the use of AI/ML techniques for network optimization, management, security, and resilience. The potential for AI/ML to transform network operations and management is discussed, as well as the associated challenges and opportunities. The course concludes with a discussion of future network architectures and protocols, such as information-centric networking, Named Data Networking (NDN), and other new approaches. The research trends and future directions in networking are also highlighted, including the potential for innovation and disruption in fields such as blockchain, IoT, and others.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Agrawal, S. K. 5G Wireless Communication System Using Machine Learning (ML). LAP LAMBERT Academic Publishing, 2020.
2. Luo, Fa-Long. Machine Learning for Future Wireless Communications. IEEE Press, 2019.
3. Braud, Tristan, et al. "Future networking challenges: The case of mobile augmented reality." *2017 IEEE 37th International Conference on Distributed Computing Systems (ICDCS)*. IEEE, 2017.
4. Husen, Arif, Muhammad Hasanain Chaudary, and Farooq Ahmad. "A survey on requirements of future intelligent networks: solutions and future research directions." *ACM Computing Surveys* 55.4 (2022): 1-61.
5. Misra, Satyajayant. "The future of wireless networks: architectures, protocols and services (guizani, m., et al; 2015)[book review]." *IEEE Wireless Communications* 23.1 (2016): 8-9.

Course Name:	**Advanced Federated Learning**
Course Code:	CS844
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course explores cutting-edge techniques and methodologies in federated learning, a paradigm that enables training machine learning models across decentralized

data sources while preserving privacy and data security. The course delves into the theoretical foundations, algorithmic advancements, and practical challenges of federated learning. Students will gain expertise in designing and implementing federated learning systems and addressing issues related to scalability, communication efficiency, and data heterogeneity.

Course Objectives:

- Understand advanced federated learning techniques to train models across decentralized data sources while ensuring privacy and security.
- Implement federated learning algorithms, addressing challenges such as data heterogeneity, communication efficiency, and model aggregation..
- Conduct research on novel federated learning methods and their applications, demonstrating proficiency in problem formulation, algorithm development, and experimentation.

Course Outline: Introduction to Federated Learning, Privacy and Security in Federated Learning, Federated Learning Algorithms (e.g., Federated Averaging, FedProx), Data Heterogeneity and Personalization, Communication-Efficient Federated Learning, Federated Learning for Edge and IoT Devices, Privacy-Preserving Techniques (e.g., Differential Privacy, Secure Aggregation), Scalability and Optimization in Federated Learning, Model Aggregation and Convergence Analysis, Handling Non-IID Data in Federated Learning, Federated Transfer Learning and Multi-Task Learning, Applications in Healthcare, Finance, and Autonomous Systems, Ethical and Regulatory Considerations in Federated Learning.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Konečný, Jakub, et al. Federated Learning: Challenges, Methods, and Future Directions. 1st Edition., Springer, 2021.
2. McMahan, Brendan, et al. Communication-Efficient Learning of Deep Networks from Decentralized Data. 1st Edition., Springer, 2017.
3. Yang, Qiang, et al. A Comprehensive Survey on Federated Learning: Challenges, Methods, and Applications. 1st Edition., IEEE Transactions on Neural Networks and Learning Systems, 2019.
4. Shokri, Reza, and Vitaly Shmatikov. Privacy-Preserving Federated Learning: Model and Algorithmic Perspectives. 1st Edition., Springer, 2019.

Course Name:	**Advancements in Large Language Modeling**
Course Code:	CS845
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course explores explores the latest developments and breakthroughs in the field of large-scale language models. The course covers fundamental techniques, architectural innovations, and emerging trends in natural language processing (NLP) using large language models. Students will gain hands-on experience with state-of-the-art models, such as GPT-4, BERT, and T5, and explore their applications, limitations, and future directions in NLP research and applications.

Course Objectives:

- Understand advanced techniques and architectures used in large language models for natural language understanding and generation.
- Implement large-scale language models, including pre-training and fine-tuning methods, addressing challenges such as scalability and resource management.
- Conduct research on emerging trends and advancements in large language modeling, demonstrating proficiency in model development, experimentation, and analysis.

Course Outline: Introduction to Large Language Models, Transformer Architecture and Variants, Pre-training Techniques (e.g., Masked Language Modeling, Causal Language Modeling), Fine-Tuning and Transfer Learning, Large-Scale Training and Optimization, Handling Large Datasets and Compute Resources, Model Evaluation and Metrics, Applications in Text Generation and Comprehension, Few-Shot and Zero-Shot Learning with Language Models, Multimodal and Cross-Modal Language Models, Ethical Considerations and Bias in Language Models, Future Directions and Emerging Trends in NLP, Case Studies of State-of-the-Art Models (e.g., GPT-4, BERT, T5)

Reference Material: The following is the recommended list of books (or their latest editions):

1. Vaswani, Ashish, et al. Attention Is All You Need. 1st Edition., NeurIPS, 2017.
2. Devlin, Jacob, et al. BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding. 1st Edition., NAACL, 2019.
3. Brown, Tom B., et al. Language Models are Few-Shot Learners. 1st Edition., NeurIPS, 2020.
4. Radford, Alec, et al. Learning Transferable Visual Models From Natural Language Supervision. 1st Edition., CVPR, 2021.

Course Name:	**Text Analytics**
Course Code:	CS846
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course on Text Analytics delves into the methodologies and techniques used to analyze and interpret textual data. It aims to equip students with advanced skills in natural language processing, information retrieval, and data mining as applied to textual information.

Students will explore various approaches to understanding and extracting meaningful insights from text, leveraging machine learning algorithms and statistical models. The course combines theoretical foundations with practical applications, preparing students to address complex text-based challenges in diverse domains.

Course Objectives:

- Understand advanced text analytics techniques, including sentiment analysis, topic modeling, and entity recognition.
- Develop and implement machine learning models for text classification, clustering, and sequence labeling
- Critically evaluate and interpret the results of text analytics algorithms and their impact on decision-making.

Course Outline: Introduction to Text Analytics, Text Preprocessing Techniques, Tokenization and Text Normalization, Statistical Language Models, Feature Extraction and Representation, Sentiment Analysis, Named Entity Recognition, Text Classification, Topic Modeling (LDA and Non-LDA approaches), Text Clustering and Similarity Measures, Sequence Labeling and Part-of-Speech Tagging, Text Summarization, Information Retrieval and Search Engines, Evaluation Metrics for Text Analytics, Applications in Social Media, Healthcare, and Finance, Ethical Considerations in Text Analytics.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Jurafsky, Daniel, and James H. Martin. Speech and Language Processing. 3rd Edition., Pearson, 2021.
2. Manning, Christopher D., and Hinrich Schütze. Foundations of Statistical Natural Language Processing. MIT Press, 1999.
3. Bishop, Christopher M. Pattern Recognition and Machine Learning. Springer, 2006.
4. Manning, Christopher D., Prabhakar Raghavan, and Hinrich Schütze. Introduction to Information Retrieval. MIT Press, 2008.

Course Name:	**Perception Systems for Autonomous Vehicles**
Course Code:	CS847
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course on Deep Learning-Based Perception Systems for Autonomous Vehicles focuses on leveraging deep learning techniques to enhance perception systems within autonomous vehicles. It explores how neural networks and other advanced machine learning models can be applied to improve the vehicle's ability to understand and interpret its environment,

including object detection, scene understanding, and interaction with human operators. The course integrates theoretical knowledge with practical applications, preparing students to develop and evaluate state-of-the-art perception systems for autonomous driving.

Course Objectives:

- Understand deep learning techniques to solve complex perception problems in autonomous vehicles..
- Design research on deep learning applications in autonomous vehicles, demonstrating expertise in model development, data handling, and system integration.
- Evaluate and interpret the performance of deep learning-based perception systems, including accuracy, efficiency, and robustness

Course Outline: Introduction to Deep Learning, Fundamentals of Neural Networks, Convolutional Neural Networks (CNNs) for Image Analysis, Object Detection and Localization, Semantic and Instance Segmentation, Advanced Network Architectures (e.g., YOLO, SSD, Mask R-CNN), Sensor Fusion with Deep Learning, Real-Time Processing and Inference, Transfer Learning and Domain Adaptation, Model Optimization and Deployment, Case Studies in Autonomous Vehicle Perception, Safety and Ethical Considerations in Deep Learning Applications, Integration of Perception Systems in Autonomous Vehicles.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Chen, L.-C., et al. Deep Learning for Semantic Image Segmentation. 1st Edition., Springer, 2021.
2. O'Sullivan, John, et al. Deep Learning for Computer Vision. 1st Edition., Springer, 2020.
3. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep Learning. MIT Press, 2016.
4. Deng, Li, and Dong Yu. Deep Learning: Methods and Applications. Foundations and Trends in Signal Processing, 2014.

Course Name:	**Advanced Convolutional Neural Network**
Course Code:	CS848
Credit Hours:	3
Pre-requisites:	None

Course Introduction: This course on Advanced Convolutional Neural Networks (CNNs) delves into the intricacies of CNN architectures and their applications in various domains. The course covers the latest advancements and techniques in deep learning, focusing on complex CNN architectures, optimization strategies, and their real-world applications. Students will gain a comprehensive understanding of how to design, implement, and evaluate sophisticated CNN models for tasks such as image classification, object detection, and semantic segmentation.

Course Objectives:

- Understand advanced CNN architectures and techniques to complex image analysis problems.
- Design state-of-the-art CNN models, including those with novel layers and optimization strategies.
- Conduct research on CNN advancements, demonstrating expertise in model development, training, and application to real-world scenarios.

Course Outline: Introduction to Convolutional Neural Networks, Deep Architectures and Layer Designs, Advanced CNN Architectures (e.g., ResNet, DenseNet, EfficientNet), Transfer Learning and Fine-Tuning, CNN Optimization Techniques (e.g., Learning Rate Schedulers, Regularization), Object Detection Networks (e.g., YOLO, Faster R-CNN), Semantic and Instance Segmentation (e.g., U-Net, Mask R-CNN), CNNs for Video and Sequence Data, Generative Models with CNNs (e.g., GANs), Real-Time CNN Processing and Inference, Case Studies and Applications, Evaluation Metrics and Model Analysis, Future Trends and Emerging Techniques.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep Learning. 1st Edition., MIT Press, 2016.
2. Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. ImageNet Classification with Deep Convolutional Neural Networks. 1st Edition., MIT Press, 2012.
3. O'Sullivan, John, et al. Deep Learning for Computer Vision. 1st Edition., Springer, 2020.
4. Chen, L.-C., et al. Deep Learning for Semantic Image Segmentation. 1st Edition., Springer, 2021.

Course Name:	**Creativity, Innovation and Professional Development in Software Engineering**
Course Code:	CS849
Credit Hours:	3
Pre-requisites:	None

Course Introduction: Creativity and innovation drive the evolution of software engineering, leading to better solutions, improved processes, and new opportunities. Embracing both with professional software development practices and skills allows engineers to tackle complex challenges and deliver impactful software solutions.

Course Objectives: This course is aimed at training students in soft skills:

- To enhance problem solving skills for developing enhanced user experience
- To incorporate code elegance and efficiency using innovative features and functionality:

- To use advanced technologies integration for optimization and efficiency and improved development processes
- For cost reduction and resource management and enhanced collaboration and remote work

Course Outline: Creativity and Rationale in Software Design, Creativity Dimensions, Creative Thinking, Design Thinking and Customer Experience Design, Branding. Innovation: Problem Solving, Critical Thinking. Innovation and Portfolio Management, Exploring new technologies, tooling and automation. Balancing creativity and innovation. Professional Development Skills: Core Soft Skills For Software Developers (Leadership Skills, Conversation, Presentation, Meeting, Decision Making, Teamwork Skills, Intercultural Communication, Presentation, Feedback And Reflection Skills), Teamwork/Group Dynamics. Techniques and role of AI.

Reference Material: The following is the recommended list of books (or their latest editions):

1. Groeneveld, Wouter. The Creative Programmer. Simon and Schuster, 2023
2. Gupta, Varun, and Chetna Gupta. Emerging Technologies for Innovation Management in the Software Industry. IGI Global, 2022
3. Doglio, Fernando. Skills of a Successful Software Engineer. Simon and Schuster, 2022
4. Online research material.