M.Sc. in Intelligent Systems Engineering Curriculum

Thesis Option (34 Credit Hours):

A. Mandatory Courses (25 Credit Hours):

Course No.	Course Title	Credit Hours	Prerequisite
22700	Seminar & Research Methodology	1	-
22701	Embedded Systems Design	3	-
22773	Intelligent Systems	3	-
22760	Applied Machine Learning	3	-
22771	Autonomous Systems	3	22701
22730	Information and Systems Security	3	-
22799	Thesis	9	Finish 12 Credits + 22700 (Co-requisite)

B. Elective Courses (9 Credit Hours):

Course No.	Course Title	Credit Hours	Prerequisite
25710	Wireless Networks Technologies	3	-
22761	Computer Vision	3	-
22762	Big Data Analytics	3	-
22702	Real-Time Computing	3	-
22723	Computer Hardware Design	3	-
22703	Advanced Computer Architecture	3	-
22721	High-Performance Computing	3	-
22712	Cloud Computing	3	-
22772	Advanced Deep Learning	3	22760
24704	Digital Control	3	-
21702	VLSI Design	3	-

Course No.	Course Title	Credit Hours	Prerequisite
23708	Wireless IoT	3	-
25720	Wireless Networks Security	3	-
22711	Computer Communications and Networks	3	-
25730	Information Security Management Systems	3	-
25750	Blockchain Technologies	3	-
22732	Reverse Engineering	3	-
22731	Industrial Control Systems Security	3	-
20731	Advanced Numerical & Statistical Methods	3	-
22780	Special Topics in Intelligent Systems (1)	3	-
22781	Special Topics in Intelligent Systems (2)	3	-
22782	Special Topics in Computer Engineering (1)	3	-
22783	Special Topics in Computer Engineering (2)	3	-
22722	Quantum Computing	3	-
22740	Law, Science and Technology	3	-

Comprehensive Exam Option (34 Credit Hours):

A. Mandatory Courses (25 Credit Hours):

Course No.	Course Title	Credit Hours	Prerequisite
22700	Seminar & Research Methodology	1	-
22701	Embedded Systems Design	3	-
22773	Intelligent Systems	3	-
22760	Applied Machine Learning	3	-
22771	Autonomous Systems	3	22701
22730	Information and Systems Security	3	-
22772	Advanced Deep Learning	3	22760
22712	Cloud Computing	3	-
22792	Project	3	Finish 22 Credits (including 22700)
22791	Comprehensive Exam	0	Per Exam Regulations

B. Elective Courses (9 Credit Hours):

Course No.	Course Title	Credit Hours	Prerequisite
22761	Computer Vision	3	-
22762	Big Data Analytics	3	-
22702	Real-Time Computing	3	-
22723	Computer Hardware Design	3	-
22703	Advanced Computer Architecture	3	-
22721	High-Performance Computing	3	-
24704	Digital Control	3	-
21702	VLSI Design	3	-
23708	Wireless IoT	3	-
25710	Wireless Networks Technologies	3	-

Course No.	Course Title	Credit Hours	Prerequisite
25720	Wireless Networks Security	3	-
22711	Computer Communications and Networks	3	-
25730	Information Security Management Systems	3	-
25750	Blockchain Technologies	3	-
22732	Reverse Engineering	3	-
22731	Industrial Control Systems Security	3	-
20731	Advanced Numerical & Statistical Methods	3	-
22780	Special Topics in Intelligent Systems (1)	3	-
22781	Special Topics in Intelligent Systems (2)	3	-
22782	Special Topics in Computer Engineering (1)	3	-
22783	Special Topics in Computer Engineering (2)	3	-
22722	Quantum Computing	3	-
22740	Law, Science and Technology	3	-

*** Course Description:**

22700	**Seminar & Research Methodology**
	Pre-requisite: None
	Credit Hours: 1
	This course aims to expose students to the latest research and developments in intelligent systems engineering. In addition, the seminar covers research methodologies needed to prepare the students for their master's thesis. It also gives them a forum to present their research ideas and learn how to critique others' work academically. Additionally, students practice improving their presentation, communication, and writing skills for academic research.

22701	**Embedded Systems Design**
	Pre-requisite: None
	Credit Hours: 3
	Microprocessor-Based Embedded Systems Design. Hardware and Software Design using 16-bit or higher MCUs. Embedded hardware and software components. Design requirements, constraints and standards. Conventional vs. Model-Based Design approaches. Embedded Software Design and programming using low-level and high-level programming languages. Model-Based and autocode generation approaches for rapid prototyping. Advanced topics in embedded systems such as Real-time Operating Systems (RTOS), multi-tasking application software, main loop designs, inter-task communication, cooperative and priority pre-emptive designs, Controller Area Networks (CAN).

22773	**Intelligent Systems**
	Pre-requisite: None
	Credit Hours: 3
	This course introduces the basics of AI, including Agent-Based modeling, Multi-Agent Systems, knowledge, and reasoning. The course covers multiple computational intelligence techniques used for modeling, optimizing, and controlling intelligent systems, such as Evolutionary Computing, Bio-inspired algorithms, Fuzzy Logic, and Neural Networks. In addition, the course covers the basics of systems engineering and Model-Driven Development with case studies in intelligent systems.

22760	**Applied Machine Learning**
	Pre-requisite: None
	Credit Hours: 3
	This course starts with a quick recap of the machine learning fundamentals in supervised and unsupervised ML techniques and their basic performance metrics. Then, advanced topics in machine learning, such as regularization models and dropout, optimizers, transfer learning, bagging, boosting, stacking, and recommender systems, are covered. In addition, the course introduces deep neural network architectures like CNNs, RNNs, LSTM, autoencoders, and GANs. And how these architectures can be trained and applied in intelligent systems. Finally, it covers Reinforcement learning, Markov Decision Process, Q-learning, and Deep Q-networks (DQN).

22771	**Autonomous Systems**
	Pre-requisite: 22701
	Credit Hours: 3
	Mobile robotics and autonomous systems concepts. Challenges of Mobile Autonomous Robots, Locomotion and Manipulation, Fundamental theoretical concepts: Configuration Space, Rigid-Body Motions, Degrees-of-Freedom, Forward Kinematics, Inverse Kinematics, Kinematics modeling, Rotation matrices, Dynamics, Trajectory Generation, Motion Planning, Robot Feedback Control, Robot Manipulation, Wheeled Mobile Robots, Modeling and Simulation tools, Basic sensors, wheel encoders, inertial measurement units (IMU), GPS, LIDAR, and cameras. Recent advances in robotics and autonomous systems, in addition to sample applications such as Unmanned Aerial and Ground Vehicles. The course will have a lab component and a team design project.

22730	**Information and Systems Security**
	Pre-requisite: None
	Credit Hours: 3
	This course offers an in-depth exploration of the principles and practices essential to safeguarding information systems. Students will comprehensively understand foundational information security concepts, common attack techniques, and system vulnerabilities. The curriculum covers a wide range of topics, including security policies, cryptographic tools, access control mechanisms, software security, operating system security, and the legal and ethical considerations in information system security. Through theoretical knowledge and practical applications, this course prepares students to effectively protect and secure information systems against evolving threats.

22799	**Thesis**
	Pre-requisite: Finish 12 Credits Co-requisite: 22700
	Credit Hours: 9
	After reviewing literature, the student defines a research problem under the supervision of a faculty member. Then he/she develops a suitable solution and writes the thesis, describing the targeted problem, his/her suggested solution and obtained results. Afterwards, the student defends his thesis against an appointed examining committee.

25710	**Wireless Networks Technologies**
	Pre-requisite: None
	Credit Hours: 3
	Overview of Wireless Networking concepts. Key technologies and standards for Wireless Personal Area Networks, Wireless Local Area Networks, Wireless Internet of Things, Wireless Body Area Networks, and Wireless Vehicular Networks.

22761	**Computer Vision**
	Pre-requisite: None
	Credit Hours: 3
	This course provides theoretical foundations and practical applications for the machine's understanding and interpretation of visual information. Topics covered include Image Representation and Understanding, Classical Image Processing (Filtering, Image Enhancement, Edge Detection, Morphological Operations), Image Classification Using Machine Learning Methods, Deep Learning Architectures and Practices for Computer Vision, Model Fitting and Optimization, Semantic Segmentation, Object Detection, Image Denoising, Image Captioning, Scene Understanding, Image Synthesis and Generative Adversarial Modeling, 3D Vision (Representation, Depth Estimation, Action Recognition, Video Captioning), Real-World Applications (Medical Imaging, Real-Time Processing (e.g., Autonomous Vehicles), Embedded Vision Systems (e.g., Robots), Forensic Analysis).

22762	**Big Data Analytics**
	Pre-requisite: None
	Credit Hours: 3
	This course introduces the terminology and principles of big data and the distributed file systems associated with it. The course also covers the latest frameworks, programming models, and scalable big data processing techniques. In addition, the typical life cycle of a big data analytics project is presented in this course, which includes data cleansing, extraction, transformation, loading (ETL), analysis, and visualization. And how this can be used to analyze and extract insights from large and complex datasets. Students will engage in intensive hands-on projects using state-of-the-art big data platforms and tools and apply these skills to solve complex, real-world problems across various domains.

22702	**Real-time Computing**
	Pre-requisite: None
	Credit Hours: 3
	Principles of real-time computing. Hard and soft real-time systems. Real-time kernels. Multitasking. Scheduling policy. Periodic and aperiodic task scheduling. Priority-driven schedulers. Earliest deadline first algorithm. Adaptive partition scheduler. High-performance systems. Reliability applications.

22723	**Computer Hardware Design**
	Pre-requisite: None
	Credit Hours: 3
	This course covers advanced techniques in digital system design using hardware description languages (HDLs) like VHDL and Verilog for modeling. It examines synthesis and optimization of combinational and sequential logic, including state machine design. Students explore high-level synthesis, register-transfer level (RTL) design, and techniques for mapping to regular structures like FSMs and pipelines. The course explores methods for partitioning and mapping digital systems to regular structures, emphasizing reconfigurable logic devices such as FPGAs. It also covers FPGA architecture, design flow, and optimization techniques. Key areas include synthesis, placement, routing, and timing closure, as well as advanced memory system design covering SRAM, DRAM, Flash, and emerging technologies. The course emphasizes performance metrics, power consumption, and reliability.

22703	**Advanced Computer Architecture**
	Pre-requisite: None
	Credit Hours: 3
	This course offers an in-depth exploration of advanced computer design principles, focusing on techniques to exploit Instruction Level Parallelism (ILP) through dynamic scheduling, branch prediction, and speculative execution. It examines multiprocessor and multi-core architectures, including symmetric multiprocessing (SMP) and chip multiprocessors (CMP), and explores hardware and software multi-threading techniques. The course covers cache coherence protocols (MESI, MOESI) and memory consistency models, advanced memory hierarchy design with multi-level caches and prefetching, and storage system design, including RAID, SSD, and non-volatile memory technologies. Comprehensive input/output system optimization, performance evaluation, and current research application are also key components.

22721	**High Performance Computing**
	Pre-requisite: None
	Credit Hours: 3
	Fundamentals of High-Performance Computing (HPC). Parallel architectures, algorithms and software tools. Performance modeling and enhancement. Message-passing and multi-threaded programming. Graphical Processing Units (GPUs) and Field Programmable Gate Array (FPGA)-based Hardware Acceleration. Parallel Algorithms and Applications.

22712	**Cloud Computing**
	Pre-requisite: None
	Credit Hours: 3
	This course provides an in-depth understanding of cloud computing. The course covers the fundamental principles, cloud-enabling technologies, architecture, delivery models, and cloud computing services. The course also covers the security aspects of cloud deployment and the business perspective of cloud usage by examining case studies of cloud computing applications across different industries. The course emphasizes advanced topics such as cloud-native architectures, microservices, container orchestration, and serverless computing.

22772	**Advanced Deep Learning**
	Pre-requisite: 22760
	Credit Hours: 3
	This course introduces advanced learning methods like One-shot learning, unsupervised feature learning, semi-supervised, self-supervised learning, transformers, attention mechanism, and variational autoencoders. Then, the course delves into advanced topics and architectures of Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Fully Convolutional Networks (FCN), and Graph Neural Networks (GNN). The course also covers pre-trained language models and Large Language Models (LLM). The course also exposes the students to different Generative Adversarial Networks (GANs) architectures. The basics of Natural language processing (NLP) techniques and their use in Sentiment analysis and text classification are presented in this course. Finally, the course concludes with topics of ML-models explainability, fairness, and ethical usage.

24704	**Digital Control**
	Pre-requisite: None
	Credit Hours: 3
	Discrete-time systems. Difference equations. Z-transform. Inverse Z-transform. Flow graphs. State variables. Transfer functions. Sampling and reconstruction of control systems. Zero-order and first-order hold. System time response characteristics. Stability analysis. Bi-linear transform. Jury's stability test. Pole assignment and state estimation. Controllability and observability. Ackerman's formula. Linear quadratic optimal control.

21702	**VSLI Design**
	Pre-requisite: None
	Credit Hours: 3
	This course covers all the major steps of the design process which includes: logic, circuit and layout design; a variety of computer aided tools are discussed and used in class; the main objective of this course is to provide VLSI design experience that includes the design of basic VLSI CMOS functional blocks, verification of the design, testing and debugging.

23708	**Wireless IoT**
	Pre-requisite: None
	Credit Hours: 3
	Overview of the Wireless Internet of Things (WIoT) concepts, standards, including benefits, limitations, and operation. Identifying the key drivers behind the development of WIoT as well as implementation. Key technology concepts of the radio interface, design requirements of the cellular IoT standards (EC-GSM-IoT, LTE-M, NB-IoT, and 5G) are explored as well as unlicensed spectrum technologies (LoRa, SigFox, Inginue, ...etc). Performance comparisons will be carried-out.

25720	**Wireless Networks Security**
	Pre-requisite: None
	Credit Hours: 3
	This course provides a thorough examination of the principles and practices of securing wireless communication systems. Students will explore the unique challenges and vulnerabilities associated with wireless networks, including Wi-Fi, Bluetooth, and Zigbee networks. Key topics include wireless network architectures, encryption techniques, authentication protocols, offensive and defensive techniques, and the latest advancements in wireless security technologies. Through a combination of theoretical knowledge and hands-on experience, students will be equipped to address and counteract security threats in various wireless communication contexts.

22711	**Computer Communications and Networks**
	Pre-requisite: None
	Credit Hours: 3
	Fundamentals of network technology based on a layered protocol stack, framing and error detection in the data link layer, automatic repeat request (ARQ) protocols, multiple access protocols, performance analysis of data link layer protocols, routing in data networks, flow and congestion control.

25730	**Information Security Management Systems**
	Pre-requisite: None
	Credit Hours: 3
	This particular course introduces the technology, operational procedures, and management practices needed for successful management of information security activities. The course is based on extensive use of standards and best practices documents that are often used to guide or mandate effective implementation of information security management systems. The course will aim to provide students in one or more of the following four areas: Information security incident management, Information risk management, Information security governance, Information security program development and management

25750	**Blockchain Technologies**
	Pre-requisite: None
	Credit Hours: 3
	This course offers an in-depth exploration of blockchain technologies, focusing on their principles, architectures, and applications. Students will learn about the decentralized nature of blockchains, consensus mechanisms, and cryptographic foundations. A significant portion will cover smart contracts, their functionality, and associated vulnerabilities and attacks. Key topics include blockchain platforms, smart contract development, common security issues such as reentrancy attacks and integer overflow, and techniques for mitigating these risks. Through theoretical knowledge and practical exercises, students will be prepared to develop and secure blockchain applications, addressing real-world challenges in this evolving field.

22732	**Reverse Engineering**
	Pre-requisite: None
	Credit Hours: 3
	This course provides a comprehensive study of reverse engineering techniques, with a particular focus on software applications. Students will learn the methodologies and tools used to analyze and deconstruct software to understand its inner workings. Key topics include disassembly, decompilation, debugging, binary analysis, and software obfuscation techniques. The course also covers identifying vulnerabilities, understanding malware behavior, and reversing Internet of Things Firmware. Through a blend of theoretical knowledge and hands-on exercises, students will gain the skills needed to dissect and analyze software, preparing them for careers in cybersecurity, software development, and digital forensics.

22731	**Industrial Control System Security**
	Pre-requisite: None
	Credit Hours: 3
	This course provides students with a comprehensive understanding of the security challenges facing industrial control systems (ICS) and the Industrial Internet of Things (IIoT). The course covers topics such as ICS network design and architecture, SCADA systems, communication protocols, and security best practices for protecting these systems. Students will learn about various cyber-attacks and defense strategies, as well as risk management and compliance with industry standards.

20731	**Advanced Numerical & Statistical Methods**
	Pre-requisite: None
	Credit Hours: 3
	Probability: probability distributions, Bayesian inference, Monte Carlo simulation method, Markov chains, transition matrix, information theory, measure of randomness – entropy, mutual information. Searching for optimal values – an introduction: Lagrange multipliers, convex optimization. Matrices: matrix analysis, singular value decomposition.

22780	**Special Topics in Intelligent Systems (1)**
	Pre-requisite: None
	Credit Hours: 3
	The objective of this course is to introduce advanced and new topics in the field of intelligent systems. The content of the material may vary from semester to semester.

22781	**Special Topics in Intelligent Systems (2)**
	Pre-requisite: None
	Credit Hours: 3
	The objective of this course is to introduce advanced and new topics in the field of intelligent systems. The content of the material may vary from semester to semester.

22782	**Special Topics in Computer Engineering (1)**
	Pre-requisite: None
	Credit Hours: 3
	The objective of this course is to introduce advanced and new topics in the field of Computer Engineering. The content of the material may vary from semester to semester.

22783	**Special Topics in Computer Engineering (2)**
	Pre-requisite: None
	Credit Hours: 3
	The objective of this course is to introduce advanced and new topics in the field of Computer Engineering. The content of the material may vary from semester to semester.

22722	**Quantum Computing**
	Pre-requisite: None
	Credit Hours: 3
	Brief history of quantum computation and quantum information. Postulates of quantum theory. Quantum model of computation. Quantum gates and quantum circuits. Quantum teleportation. Superdense coding. Quantum algorithms. Quantum error correction. Quantum cryptography. Physical implementations of quantum computers.

22740	**Law, Science and Technology**
	Pre-requisite: None
	Credit Hours: 3
	The objective of this course is to equip students with the analytical and critical tools necessary to understand and respond to complex questions of science and technology in all their legal, social, (geo)political, ethical, and cultural dimensions. Principal topics include the relationship between law, science, technology, and society, big data and global surveillance, military technologies, public discourse around science and technology, advocacy, law reform, and other critical encounters between law, science, technology, and society.

22792	**Project**
	Pre-requisite: Finish 22 Credits Hours (including 22700)
	Credit Hours: 3
	This is a practical project to be conducted by students opting for the comprehensive exam track. The project allows students to integrate knowledge gained in multiple courses into a fully functional practical project. A written report and an oral presentation are due upon the completion of the project. Projects are to be evaluated by a committee formed by the department.

22791	**Comprehensive Exam**
	Pre-requisite: Per Exam Regulations
	Credit Hours: 0
	The comprehensive examination aims to measure the student's ability to understand and make correlations between the basic and advanced concepts that he/she has acquired through his/her studies, and to apply them in solving theoretical and applied problems in his/her field of specialization.

Guidance Plan (Thesis)

First Year – First Semester			First Year – Second Semester		
Course No.	**Course Name**	**Credit Hours**	**Course No.**	**Course Name**	**Credit Hours**
22773	Intelligent Systems	3	22771	Autonomous Systems	3
22701	Embedded Systems Design	3	-	Elective Course	3
-	Elective Course	3	22760	Applied Machine Learning	3
22700	Seminar & Research Methodology	1			
Total Credits		**10**	**Total Credits**		**9**

Second Year – First Semester			Second Year – Second Semester		
Course No.	**Course Name**	**Credit Hours**	**Course No.**	**Course Name**	**Credit Hours**
22730	Information and Systems Security	3	22799	Thesis	6
-	Elective Course	3			
22799	Thesis	3			
Total Credits		**9**	**Total Credits**		**6**

Guidance Plan (Comprehensive Exam)

First Year – First Semester			First Year – Second Semester		
Course No.	**Course Name**	**Credit Hours**	**Course No.**	**Course Name**	**Credit Hours**
22773	Intelligent Systems	3	22771	Autonomous Systems	3
22701	Embedded Systems Design	3	-	Elective Course	3
-	Elective Course	3	22760	Applied Machine Learning	3
22700	Seminar & Research Methodology	1			
Total Credits		**10**	**Total Credits**		**9**

Second Year – First Semester			Second Year – Second Semester		
Course No.	**Course Name**	**Credit Hours**	**Course No.**	**Course Name**	**Credit Hours**
22730	Information and Systems Security	3	22792	Project	3
-	Elective Course	3	22712	Cloud Computing	3
22772	Advanced Deep Learning	3			
Total Credits		**9**	**Total Credits**		**6**

Second Year – Summer Semester		
Course No.	**Course Name**	**Credit Hours**
22791	Comprehensive Exam	0