COMPUTER SCIENCE (COMP)

COMP 3001 C and C++ Programming Foundations for New Graduate Students (4 Credits)
This accelerated course covers the basics of discrete mathematics including functions, relations, counting, logic, proofs etc that is necessary to attend CS graduate school. In addition, it includes an introduction to programming and algorithm analysis. Enrollment restricted to graduate students.

COMP 3002 C and C++ Foundations II for New Graduate Students (4 Credits)
This accelerated course continues to build on the basics of discrete mathematics by covering material including advanced counting, recurrences, graphs, trees, traversals, automata etc. that is necessary to attend Computer Science graduate school. In addition, it includes an introduction to additional algorithms and data structures. Prerequisite: COMP 3001.

COMP 3003 Foundations in Computer Systems (4 Credits)
This course introduces computer systems, including instruction set architectures; memory hierarchies including registers, caching, virtual memory, paging, and segmentation; number representations; binary arithmetic and operations; assembly language instructions; and pipelining in the CPU.

COMP 3004 Foundations in Discrete Structures & Algorithms (4 Credits)
Both discrete mathematics and an understanding of algorithms along with their analysis form principle foundations in computer science. In this course, the fundamentals of discrete mathematics including functions, relations, counting, logic, proofs, counting, recurrences, and probability are covered. In addition, beginning data structures and algorithms are covered including linked-lists, graphs, hash-tables, sorting, and binary search. An analysis of these data structures and algorithms is also covered through big-O notation and proof methods.

COMP 3005 Foundations in Python Programming (4 Credits)
This accelerated course covers the basics of Python programming. By the end of the course students will be able to develop, design and implement Python programs, explain the differences between data types, learn to read from and write to files, understand and use data structures, understand and use object oriented programming, and use Python packages.

COMP 3006 Python Software Development (4 Credits)
This accelerated course covers advanced Python programming for data scientists and cybersecurity professionals. Course Objectives: name and demonstrate proficiency using advanced Python programming techniques; analyze a programming task and create a development plan and high-level software design that accomplishes the task; relate common portions of the Python standard library to specific programming tasks; understand and apply aspects of the Python scientific programming ecosystem to achieve an analysis goal. Prerequisites: COMP 3005.

COMP 3007 Foundations in Data Science Mathematics I (4 Credits)
This course presents the elements of calculus essential for work in data science. Students will study differentiation and integration in the context of probability density and of optimization.

COMP 3008 Foundations in Data Science Mathematics II (4 Credits)
This course presents the elements of linear algebra and discrete math essential for subsequent coursework in data science.

COMP 3009 Essential Math for Data Science and AI (4 Credits)
The primary objective of the course is to empower students with the mathematical tools most used in data science. Students will develop an understanding of fundamental topics such as matrix operations, eigenvectors, and singular value decomposition (SVD), along with key calculus principles, including derivatives and integrals, with a focus on their applications in data science. The course also explores elements of multivariate calculus and optimization techniques to solve real-world problems, as well as probability concepts relevant to modeling uncertainty and variability in data. Additionally, students will gain exposure to implementing mathematical models using Python libraries such as NumPy, Pandas, and Matplotlib to analyze and manipulate data. By synthesizing these mathematical principles, students will be prepared for more advanced topics in data science and machine learning. Graduate student will be expected to upload a course presentation/project assignment to their individual Github portfolio.

COMP 3200 Discrete Structures (4 Credits)
Discrete mathematical structures and non-numerical algorithms; graph theory, elements of probability, propositional calculus, Boolean algebras; emphasis on applications to computer science. Prerequisites: COMP 2300 and COMP 1353 for undergraduates and COMP 3004 for graduates.

COMP 3351 Programming Languages (4 Credits)
Learn the fundamentals of programming languages through functional programming through an in-depth understanding of syntax and semantics around program structures and how programming languages are parsed and interpreted. Understand recursion as a fundamental problem-solving paradigm and the important role that higher order types and kinds play in eliminating errors and simplifying software development. Satisfies the Programming Language elective requirement. Prerequisites: COMP 2362 and COMP 2370.

COMP 3352 Elements of Compiler Design (4 Credits)
Techniques required to design and implement a compiler; topics include lexical analysis, grammars and parsers, type-checking, storage allocation and code generation. Prerequisite: COMP 3351.

COMP 3353 Compiler Construction (4 Credits)
Design and implementation of a major piece of software relevant to compilers. Prerequisite: COMP 3352.

COMP 3356 Introductory C/C++ Programming (4 Credits)
This course introduces unmanaged programming language concepts to students whose primary programming experience is in a managed language (Java/Python, etc.). Concepts like type safety, manual memory management and “unsafe” library functions are covered. Common pitfalls in these languages from which most security issues arise are explained and students gain experience in understanding such code and evaluating it for program errors. Students will also be introduced to important compiled language concepts of static/dynamic linking, compilation and debugging. Prerequisites: COMP 3006.

COMP 3361 Operating Systems I (4 Credits)
Operating systems functions and concepts; processes, process communication, synchronization; processor allocation, memory management in multiprogramming, time sharing systems. Prerequisites: for undergraduates: (COMP 2355 and COMP 2691) or COMP 2361; COMP 2370; for graduate students: COMP 3003, 3004, and 3005.

COMP 3371 Data Structures & Algorithms (4 Credits)
Design and analysis of algorithms and data structures; asymptotic complexity, recurrence relations, lower bounds; algorithm design techniques such as incremental, divide-and-conquer, dynamic programming, iterative improvement, greedy algorithms; randomized data structures and algorithms. Prerequisites: COMP 2370 or equivalent and COMP 3200.

COMP 3372 Advanced Algorithms (4 Credits)
Advanced techniques for the design and analysis of algorithms and data structures; amortized complexity, self-adjusting data structures; randomized , online, and string algorithms; NP-completeness, approximation and exact exponential algorithms; flow networks.

COMP 3381 Software Engineering I (4 Credits)
An introduction to software engineering. Topics include software processes, requirements, design, development, validation and verification and project management. Cross-listed with COMP 4381. Prerequisites: COMP 3351; COMP 3361 or COMP 2362; or instructor permission.

COMP 3382 Software Engineering II (4 Credits)
Continuation of COMP 3381. Topics include component-based software engineering, model-driven architecture, and service-oriented architecture. Prerequisite: COMP 3381.

COMP 3411 Web Programming II (4 Credits)
In this course you will learn how to develop a full-stack web application that is capable of serving dynamic content from a database. Furthermore, you will learn the core design concepts and principles that will enable you to develop scalable and easy to maintain webapplications - a set of skills that will serve you well in both your personal and professional projects in the future. Prerequisite: COMP 3410.

COMP 3412 Web Projects: Web Development III (4 Credits)
In this course you will learn how to develop, as a group, a full-stack web application that is capable of serving dynamic content from a database. We will use the MongoDB, ExpressJS, Angular, and Node.js (MEAN) software stack to work on a real-life problem presented to us by an external product owner. In the class we will use the Scrum framework for Agile development to work, as a software team, through several sprints of development. You will be peer reviewing each other throughout the course, and the product owner will also be reviewing your product through end-of-sprint demos as features are completed. The goal for this class is for it to be a fun, collaborative, and educational environment that demonstrates what it is like to work as a real software team. Prerequisite: COMP 3411.

COMP 3421 Database Organization & Management I (4 Credits)
An introductory class in database management systems covering both relational and non-relational databases with an emphasis on relational. Topics include database design, ER modeling, relational algebra, SQL, scripting, and embedded SQL. Each student will design, load, query and update a nontrivial database using a relational database management system (RDBMS). In addition, an introduction to a NoSQL database will be included. Graduate students will read one or two relevant technical papers and write a summary report. Prerequisites: for undergraduates: COMP 1353 or COMP 2673; for graduates: COMP 3005 or COMP3006 (MS Data Science).

COMP 3424 NoSQL Databases (4 Credits)
In this course, students learn what NoSQL databases are, learn to identify the differences between them, and gain a fundamental understanding between SQL, relational databases, and NoSQL databases. Students further explore which type of NoSQL database is the correct one given a use-cases, examining types, methods of communicating with it, contrasts to other NoSQL databases, performance and scalability. Prerequisites: for undergraduates, COMP 2355 or COMP 2361; for graduates: COMP 3005.

COMP 3431 Data Mining (4 Credits)
Data Mining is the process of extracting useful information implicitly hidden in large databases. Various techniques from statistics and artificial intelligence are used here to discover hidden patterns in massive collections of data. This course is an introduction to these techniques and their underlying mathematical principles. Topics covered include: basic data analysis, frequent pattern mining, clustering, classification, and model assessment. Prerequisites: COMP 2370.

COMP 3621 Computer Networking (4 Credits)
An introduction to computer networks with an emphasis on Internet protocols. Topics include: internet design, application layer protocols such as SMTP and HTTP, session layer protocols including TCP and UDP, the internet protocol (IP), link layer technology such as Ethernet, and security issues related to networking. Programming experience of client/server architectures using sockets and TCP/UDP through projects is emphasized. Prerequisites: for undergraduates: (COMP 2355 or COMP 2361) and COMP 2370; for graduates COMP 3004 and COMP 3006. Cross listed with COMP 4621.

COMP 3681 Networking for Games (4 Credits)
Implementing the networking code for multiplayer games is a complex task that requires an understanding of performance, security, game design, and advanced programming concepts. In this course, students are introduced to the networking stack and how this is connected to the Internet, learn how to write protocols for games, and implement several large games using a game engine that demonstrate the kind of networking and protocols required by different genres of games. In addition, tools are introduced that help understand and debug networking code, simplify the creation of protocols, and make the development of networking code easier.

COMP 3701 Topics in Computer Graphics (4 Credits)

COMP 3702 Topics in Database (4 Credits)

COMP 3703 Topics-Artificial Intelligence (4 Credits)

COMP 3704 Advanced Topics: Systems (4 Credits)

COMP 3705 Topics in Computer Science (1-4 Credits)

COMP 3731 Computer Forensics (4 Credits)
Computer Forensics involves the examination of information contained in digital media with the aim of recovering and analyzing latent evidence. This course will provide students an understanding of the basic concepts in preservation, identification, extraction and validation of forensic evidence in a computer system. The course covers many systems level concepts such as disk partitions, file systems, system artifacts in multiple operating systems, file formats, email transfers, and network layers, among others. Students work extensively on raw images of memory and disks, and in the process, build components commonly seen as features of commercial forensics tools (e.g. file system carver, memory analyzer, file carver, and steganalysis). Prerequisites: COMP 3361; COMP 2355 or 2361 for undergraduates; COMP 3006 for graduates.

COMP 3801 Introduction Computer Graphics (4 Credits)
Fundamentals of 3D rendering including the mathematics behind coordinate systems, projections, clipping, hidden surface removal, shadows, lighting models, shading models, and mapping techniques. Significant use of 3D APIs through shader programming is covered along with the basics of 3D model representation and animations. Satisfies "Advanced Programming" requirements for graduate students. Prerequisites: COMP 2370, MATH 1952 or 1962.

COMP 3820 Introduction to Game Programming (4 Credits)
Learn the fundamentals of game programming by creating 2D and 3D games using a modern game engine. Topics include working with 2D/3D art assets, character controllers, physics, camera systems, 2D and 3D animation integration, lighting, audio, user interfaces, artificial intelligence, and level design. The emphasis in this course is on game programming and implementing game mechanics in fully-working games. Prerequisites: COMP 2381 and COMP 2821.

COMP 3821 Game Programming I (4 Credits)
A continuation of Introduction to Game Programming, this course introduces advanced topics that are essential as future game programmers. Students have the opportunity to learn game engine architecture, 2D and 3D linear algebra for graphics, sprites, 2D and 3D animations, input handling, finite state machines, particle systems, user interfaces, game audio, and artificial intelligence for games. Prerequisites: COMP 2370 and COMP 3820.

COMP 3822 Game Programming II (4 Credits)
In this course, students learn how to work with a 3D game engine and build 3D games. Topics include algorithms, mathematics for 3D game engines, scene management, animations, 3D shaders, particle systems, physics for games, UIs, terrain systems, and working with higher-level scripting languages on top of the low-level implementation language. Prerequisites: COMP 3821. Suggested corequisite or prerequisite: COMP 3801.

COMP 3904 Internship/Co-Op in Computing (0-10 Credits)
Experiential learning through employment with a company to work in computer science. Students are expected to find the internship/co-op and connect their hiring manager with an advisor in the department to get approval. Requirements for approval include a job description that shows what will be accomplished throughout the quarter and a final report from the hiring manager to report on their performance so that a grade may be assigned. Prerequisites: COMP 2370 and approval of department. MS Data Science students: practical experience working under the supervision of data science employer and a data science faculty advisor. Learning outcomes will be assessed via student work such as summary reports, literature reviews, presentations, code notebooks and/or repositories. Prerequisites: permission of Data Science Faculty Director.

COMP 3991 Independent Study (1-10 Credits)
Cannot be arranged for any course that appears in the regular course schedule for that particular year.

COMP 4100 Human-Computer Interaction (4 Credits)
Introduces students in computer science and other disciplines to principles of and research methods in human-computer interaction (HCI). HCI is an interdisciplinary area concerned with the study of interaction between humans and interactive computing systems. Research in HCI looks at cognitive and social phenomena surrounding human use of computers with the goal of understanding their impact and creating guidelines for the design and evaluation of software, interfaces, physical products, and services in industry. No prerequisites are required to take the course and students from all disciplines are welcome. Cross listed with COMP 3100.

COMP 4333 Parallel and Distributed Computing (4 Credits)
Current techniques for effective use of parallel processing and large scale distributed systems. Programming assignments will give students experience in the use of these techniques. Specific topics will vary from year to year to incorporate recent developments. This course qualifies for the Computer Science "Advanced Programming" requirement. Prerequisites: COMP2370 and COMP2355, or equivalent.

COMP 4334 Parallel and Distributed Computing for Data Science and AI (4 Credits)
Current techniques for effective use of parallel processing and large-scale distributed systems for data science. Programming assignments will give students experience in the use of these techniques. Specific topics will vary from year to year to incorporate recent developments. This course is not to be used for the MS Computer Science. Graduate students are required to contribute at least one course assignment to their personal Github portfolio. Prior completion or concurrent enrollment in COMP 4432 is strongly recommended. Prerequisite: COMP 3006.

COMP 4355 Advanced System Programming (4 Credits)
This course covers programming in a UNIX environment, including use of common command line utilities, scripting, source control via Git, and integration of POSIX system calls into C/C++ code. These features will be leveraged to solve practical problems cleanly and efficiently. More emphasis will be placed on using these features than on how those features work. Prerequisites: COMP 3001, 3002, 3003, and 3004.

COMP 4370 Algorthmic Problem Solving (4 Credits)
The course is intended for students who are familiar with programming syntax but have not had much experience writing computer programs to solve a problem stated as a high-level description. The course will run through multiple such problem descriptions, discuss the design of programs to solve those problems using popular data structures, and have students implement those designs using a programming language. This course does not count for MS Computer Science requirements. Prerequisites: COMP 3001, 3002, 3003, and 3004.

COMP 4372 Advanced Algorithms (4 Credits)
Advanced techniques for the design and analysis of algorithms and data structures; amortized complexity, self-adjusting data structures; randomized , online, and string algorithms; NP-completeness, approximation and exact exponential algorithms; flow networks. Prerequisite: COMP 3371. Cross listed with COMP 3372.

COMP 4384 Secure Software Engineering (4 Credits)
This course is concerned with systematic approaches for the design and implementation of secure software. While topics such as cryptography, networking, network protocols and large scale software development are touched upon, this is not a course on those topics. Instead, this course is on identification of potential threats and vulnerabilities early in the design cycle. The emphasis in this course is on methodologies and paradigms for identifying and avoiding security vulnerabilities, formally establishing the absence of vulnerabilities, and ways to avoid security holes in new software. There are programming assignments designed to make students practice and experience secure software design and development. Prerequisites: COMP 3006, COMP 3361, COMP 3356.

COMP 4401 Introduction to Python for Data Science (2 Credits)
This eight-week course enables aspiring graduate students in data science to meet their Python programming proficiency prior to matriculation. Students who complete this course will be able to write and modularize code, design efficient control structures, perform basic data operations, debug errors, distinguish data types and basic structures, and work within an integrated development environment.

COMP 4431 Data Mining (4 Credits)
Data Mining is the process of extracting useful information implicitly hidden in large databases. Various techniques from statistics and artificial intelligence are used here to discover hidden patterns in massive collections of data. This course is an introduction to these techniques and their underlying mathematical principles. Topics covered include: basic data analysis, frequent pattern mining, clustering, classification, and model assessment. Prerequisites: COMP 4441 and COMP 4581.

COMP 4432 Machine Learning (4 Credits)
This course will give an overview of traditional machine learning techniques, their strengths and weaknesses, and the problems they are designed to solve. This will include the broad differences between supervised/unsupervised and reinforcement learning as well as associated learning problems such as classification and regression. Techniques covered, at the discretion of the instructor, may include approaches such as linear and logistic regression, support vector machines, kNN, decision trees, random forests, Naive Bayes, EM, k-Means, and PCA. After course completion, students will have a working knowledge of these approaches and experience applying them to learning problems. Graduate students will contribute and assignment or project to a digital portfolio on Github. Prerequisites: MATH 3009 and COMP 3006.

COMP 4433 Data Visualization (4 Credits)
This course explores visualization techniques and theory. The course covers how to use visualization tools to effectively present data as part of quantitative statements within a publication/report and as an interactive system. Both design principles (color, layout, scale, and psychology of vision) as well as technical visualization tools/languages will be covered. Graduate students will contribute one assignment or project to a personal portfolio on Github. Prerequisite: COMP 3006.

COMP 4441 Introduction to Probability and Statistics for Data Science & AI (4 Credits)
The course introduces fundamentals of probability for data science. Students survey data visualization methods and summary statistics, develop models for data, and apply statistical techniques to assess the validity of the models. The techniques will include parametric and nonparametric methods for parameter estimation and hypothesis testing for a single sample mean and two sample means, for proportions, and for simple linear regression. Students will acquire sound theoretical footing for the methods where practical, and will apply them to real-world data, primarily using R. Graduate students will contribute a course assignment or project to their personal portfolio in Github. Prerequisite: COMP 3009.

COMP 4442 Advanced Probability and Statistics for Data Science and AI (4 Credits)
This course builds on material in Probability and Statistics 1. Students will carry out model fitting and diagnostics for multiple regression, ANOVA, ANCOVA, and generalized linear models. Dimension reductions techniques such as PCA and Lasso are introduced, as are techniques for handling dependent data. The course introduces the principles of resampling and Bayesian Analysis. Students will acquire sound theoretical footing for the methods where practical, and will apply them to real-world data, primarily using R. Enforced Prerequisites: COMP 4441.

COMP 4447 Data Science Tools 1 (4 Credits)
Organizations are using data science to extract actionable insight from data. To highlight the hidden patterns in the data, this course equips students with essential sills for data collection, cleanup, transformation, feature engineering, summarization, visualization, and collaboration. Students will do assignments and a final project. This is a hands-on course. Students will use Python libraries, Linux commands, API requests, web-scraping, GitHub and various data sets to perform these activities. Prerequisites: COMP 3006.

COMP 4448 Data Science Tools 2 (4 Credits)
Building a successful predictive model is a multi-faceted process. This course focuses on hypothesis testing and the development of predictive models. Students will learn the data science process for model development while learning to program a variety of predictive algorithms. Students will do assignments and a final project. This is a hands-on course. Students will use Python libraries, Linux commands, and various data sets to perform these activities. Prerequisite: COMP 4447.

COMP 4449 Data Science & AI Capstone (4 Credits)
Data Science Capstone provides students an opportunity to demonstrate their expertise as data scientists. Students are expected to integrate prior knowledge and skills to design, develop, test, and present 'full-cycle' data science products, and apply them in real-world contexts. This includes assessing and communicating their value to decision-making. Two sets of challenges of increasing complexity are presented as mid-term and term projects. These two projects are implemented, documented, tested, and presented by the students or students' two-person teams. Prerequisites: COMP 4432.

COMP 4450 Machine Learning Operations (4 Credits)
This course introduces the engineering and deployment of machine learning systems. Students will learn essential technical and organizational skills needed to develop and deploy ML solutions, progressing from fundamental concepts through to practical implementation. Key topics include ML project lifecycle management, containerization, web application development, data management strategies, and cloud deployment. Focus will be given to the application of industry-standard tools and best practices for building production-ready machine learning systems. Prerequisites: COMP 3421 and COMP 4432.

COMP 4455 Shell Scripting and System Tools (4 Credits)
This course covers navigating and utilizing tools in a UNIX environment, including use of common command line utilities, Bash and Python shell scripting, source control via Git, pipes and I/O redirection, networking in Python and OS multi-processing/multi-threading. More emphasis will be placed on using these tools than on how those tools work. Prerequisite: COMP 3006.

COMP 4456 Deep Learning for Sequence Data (4 Credits)
This course introduces modern approaches to analyzing sequential data, with a focus on deep learning methods for time series and natural language processing. Students will develop practical skills in building and implementing neural network models for sequential data analysis, while gaining a thorough understanding of the underlying concepts. Through hands-on projects and real-world applications, students will learn to process, analyze, and generate predictions from various types of sequential data. The course emphasizes practical implementation and modern deep learning frameworks, bridging the gap between traditional statistical methods and contemporary neural network approaches. Prerequisite: COMP 4432.

COMP 4490 Understanding AI (4 Credits)
Understanding Artificial Intelligence provides a comprehensive introduction to artificial intelligence (AI) for students of all backgrounds. This course explores the diverse approaches to AI, including rule-based systems, expert systems, knowledge representation, search algorithms, machine learning, natural language processing, robotics, and human-AI interaction. Students will gain hands-on experience with AI tools and applications while critically examining their impact on society. The course emphasizes the capabilities, limitations, and ethical considerations of AI, preparing students to engage thoughtfully with AI technologies in various fields.

COMP 4491 Applications of Generative AI (4 Credits)
Applications of Generative Artificial Intelligence is a hands-on course explores the transformative power of generative artificial intelligence (AI) across various industries. Students will engage directly with generative AI tools and techniques, including text generation, image synthesis, music composition, code generation, and more. Through practical exercises, projects, and case studies, students will develop a deep understanding of how generative AI can enhance creativity, automate workflows, and drive innovation in diverse fields. This course is designed for students who have completed COMP 4490 and want to apply AI in practical, industry-relevant contexts. Prerequisite: COMP 4490 and non-majors.

COMP 4495 AI Design Project (4 Credits)
The Artificial Intelligence Design Project serves as the culminating experience for students who have completed COMP 4490 and COMP 4491. This course provides an opportunity for students to apply their AI knowledge and skills to a self-directed project in a domain of their choice. Over ten weeks, students will identify a problem, design an AI-driven solution, and develop a functional prototype or proof-of-concept. Emphasizing creativity, problem-solving, and ethical considerations, this capstone-style course enables students to make a tangible impact in their field. The course includes milestone check-ins, peer reviews, and a final presentation to showcase their work. Pre-requisite: COMP 3490 and COMP 3491.

COMP 4501 Introduction to Artificial Intelligence (4 Credits)
Introduces a variety of Artificial Intelligence concepts and techniques, relevant to a broad range of applications. Students survey multiple techniques including search, knowledge representation and reasoning, probabilistic inference, machine learning, and natural language processing. Examines concepts of constraint programming, evolutionary computation and non-standard computation. Graduate students will also consider current political, economic, and societal issues related to artificial intelligence through reading and discussion. Prerequisites: COMP 3004 or equivalent.

COMP 4525 Adv. Human Centered AI - Mind Reading Machines (4 Credits)
This course explores a key intersection of Artificial Intelligence (AI) and Human-Computer Interaction (HCI). How can AI enhance our interactions with computers by catering to our individual needs and differences? Can we teach computers to understand people's thoughts and feelings to improve overall interaction? Humans often adjust their communication when they notice the person they're talking to is frustrated—why can't computers do the same? In this interdisciplinary, research-focused course, you will read, present, and discuss seminal papers at the intersection of AI and HCI, including (but not limited to) affective computing, physiological computing, augmented cognition, and multimodal interaction. ## Learning Objectives (General Goal) Demonstrate a broad understanding of the intersections between Human-Computer Interaction and Artificial Intelligence, with an emphasis on user modeling. (LO1) Recognize how theories from fields outside of Computer Science can inform and enhance Computer Science practices. (LO2) Develop knowledge of state-of-the-art user modeling techniques, including practical applications and associated challenges. (LO3) Develop critical thinking and scientific communication skills related to current AI topics, including science writing and scientific discourse. (LO4 - Graduate Students Only) Consider how the intersection of Humans and Artificial Intelligence impacts your own research and work. Consider the ethical challenges of your own work more deeply and how these may be mitigated.

COMP 4531 Deep Learning: Model Design and Application (4 Credits)
This course addresses the foundational concepts and components of Artificial Neural Networks (ANN), highlighting their capabilities, strengths, and weaknesses as a machine learning algorithm. Students taking this course will develop ANN models from scratch in Python as a basis for understanding their design as well as the underlying mechanics and calculations that shape their behavior. Key topics such as forward-backward propagation, loss function characteristics and optimization will be considered in relation to model design and computational efficiency as well as to problems such as exploding and vanishing gradients. Training strategies (e.g., dropout, initialization, batch normalization) will further enable students to assess trade-offs in model bias & variance. Coupled with hands-on assignments, these building blocks provide the knowledge and skills required to effectively design and implement ANN models that are ethically and technically sound. As well as foreground important architectures such as Convolutional ANNs, Recurrent ANNs, LSTMS, and Transformers as well as their applicability to modern problems. Student learning and proficiency will be assessed based on a combination of quizzes, coding assignments, exams, and a culminating project. Prerequisite: COMP 4432.

COMP 4581 Algorithms for Data Science & Artificial Intelligence (4 Credits)
This course introduces the design and analysis of algorithms within the context of data science and artificial intelligence. Topics include; asymptotic complexity and algorithm design techniques such as incremental, divide and conquer, dynamic programming, randomization, greedy algorithms, and advanced sorting techniques. Examples to illustrate techniques are drawn from multi-dimensional clustering (k-means and probabilistic), regression, decision trees, order statistics, data mining using apriori algorithms, and algorithms for generating combinatorial objects. Graduate students will contribute at least 1 assignment to their personal portfolio on Github. Prerequisite: COMP 3006.

COMP 4591 Computational Geometry (4 Credits)
This class deals with the design and implementation of efficient algorithms for problems defined over geometric objects, such as points, lines, polygons, surfaces, etc. The methods and algorithms covered find applications in many areas, including computer graphics (e.g., hidden surface removal), computer-aided design and manufacturing (e.g., 3D printing), machine learning (e.g., supervised and unsupervised classification), geographic information systems (e.g. terrain visibility), robotics (e.g., motion planning), data mining (e.g., dimensionality reduction), and computer vision (3D reconstruction), to name a few. Fundamental geometric problems such as partitioning, proximity, intersection, convexity, visibility, point location, and motion planning are focused on. Efficient data structures and algorithms for their solutions and design techniques germane to the field, such as divide-and-conquer, plane sweep, randomization, duality, etc. are discussed in detail. Practical methods for the robust implementation of geometric algorithms are also covered. Prerequisites: COMP 3200 and COMP 3371. This course satisfies the Theory requirement for graduate students.

COMP 4600 Seminar in Computer Science (0-4 Credits)
Preparation and presentation of lectures on some aspect of current research in computer science; topics not generally encountered in formal courses, may include robotics, pattern recognition, parallel processing, computer applications. 10- to 15- page paper with bibliography required.

COMP 4621 Computer Networking (4 Credits)
The Internet is arguably the most transformative invention in recent history and is at its core a massive global computer network (of networks). Students in this course learn how the Internet works, from the highest-level application layer to the lowest-level hardware layer. Topics covered include the OSI and TCP/IP reference models, physical transmission methods, error detection and correction, addressing, routing algorithms, congestion control and more. Prerequisites: COMP 3006, COMP 3361 (or instructor approval). Cross listed with COMP 3621.

COMP 4701 Special Tpcs-Computer Graphics (1-4 Credits)

COMP 4702 Advanced Topics-Database (3 Credits)

COMP 4703 Adv Topics-Artificial Intell (1-4 Credits)

COMP 4704 Advanced Topics-Systems (3-4 Credits)

COMP 4705 Advanced Topics-Programming (1-4 Credits)

COMP 4709 Special Tpcs-Computer Security (1-4 Credits)

COMP 4711 Special Topics in Data Science and AI (4 Credits)
Special Topics in Data Science highlights selected methods & applications in machine learning that are not specifically addressed within the curriculum. Areas of study may include, but are not limited to, natural language processing, recommender systems, data science for social justice, machine learning operations, generative AI and more. Special Topics in Data Science will be offered as an elective on an intermittent basis. Prerequisites: COMP 4432 and COMP 4441.

COMP 4721 Computer Security (4 Credits)
This course gives students an overview of computer and system security along with some cryptography. Some network security concepts are also included. Other concepts include coverage of risks and vulnerabilities, policy formation, controls and protection methods, role-based access controls, database security, authentication technologies, host-based and network-based security issues. Prerequisites: COMP 3006, COMP 3361 (or advisor/ instructor approval).

COMP 4722 Network Security (4 Credits)
Network Security covers tools and techniques employed to protect data during transmission. It spans a broad range of topics including authentication systems, cryptography, key distribution, firewalls, secure protocols and standards, and overlaps with system security concepts as well. This course will provide an introduction to these topics, and supplement them with hands-on experience. In addition, students will perform an extensive analysis, or development of a security related product independently. Prerequisites: COMP 4721.

COMP 4723 Ethical Hacking (4 Credits)
Ethical hacking is the process of probing computer systems for vulnerabilities and exposing their presence through proof-of-concept attacks. The results of such probes are then utilized in making the system more secure. This course will cover the basics of vulnerability research, foot printing targets, discovering systems and configurations on a network, sniffing protocols, firewall hacking, password attacks, privilege escalation, rootkits, social engineering attacks, web attacks, and wireless attacks, among others. Prerequisites: COMP 3361, or COMP 3001, 3002, 3003, and 3004.

COMP 4724 Systems Security Management (4 Credits)
This course covers basic system administration tasks on a Unix environment, with a special focus on command line navigation, file/process access control, setting up network configurations, and managing services related to networks and their security. Prerequisites: COMP 3001, 3002, 3003, and 3004.

COMP 4799 Capstone Project in Cybersecurity (1-8 Credits)
The purpose of the cybersecurity capstone project is to provide an integrative experience that ties together the learning outcomes from academic coursework undertakings and industry skills necessary to be productive in delivering an end product. Students will engage in one of many options available, such as involvement in a research project, a case study, a product development project, or an extensive survey paper. Capstone projects are presented at the end of the quarter in front of a representative group. Prerequisites: COMP 3001, 3002, 3003, and 3004.

COMP 4991 Independent Study (1-12 Credits)
Independent study on a particular topic supervised by a faculty member. Student must find a faculty member who will supervise work on the topic. Cannot be arranged for any course that appears in regular course schedule for that particular year.

COMP 4995 Independent Research (1-17 Credits)
Research projects undertaken in conjunction with a faculty member.

COMP 5991 Independent Study (1-17 Credits)

COMP 5995 Independent Research (1-17 Credits)