

MATHEMATICS AND COMPUTER SCIENCE

Faculty

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 Stephen Bricher, Ph.D.
 Malek Daaboul, M.S. (Non-Tenure Track)
 Daniel Ford, M.S.
 Michael Hitchman, Ph.D.
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 Chuck London, Ph.D. (Chair)

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Instructional Associate

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"Born of [our] primitive urge to seek order in [our] world, mathematics is an ever-evolving language for the study of structure and pattern. Grounded in and renewed by physical reality, mathematics rises through sheer intellectual curiosity to levels of abstraction and generality where unexpected, beautiful, and often extremely useful connections and patterns emerge. Mathematics is the natural home of both abstract thought and the laws of nature. It is at once pure logic and creative art." *Essays in Humanistic Mathematics*, Alvin White, ed, MAA, 1993

The study of mathematics, data science, and computer science give students the needed background to understand modern, complex scientific and social issues; provides students practice and training in the use of logic and critical thought; and helps students develop sound problem-solving abilities. Students profit from developing these abilities, and no student should be limited in his or her aspirations due to an insufficient background in mathematics or computer science.

The Linfield Department of Mathematics and Computer Science maintains an active program preparing students for graduate study in mathematics, data science, or computer science, careers in teaching, and professions in which the critical-thinking skills developed in mathematics and computer science are highly valued. Individual attention and sound preparation in the foundations of mathematics are key elements in the success of our students. The department provides a rich and supportive academic environment fostering a community of learners, including students for whom mathematics or computer science is their primary focus and those for whom mathematics or computer science is crucial for their chosen area of study.

Student Recognition

The Senior Science Prize was established to encourage students in the natural sciences and mathematics to plan for graduate study and eventual careers in the field of pure and applied science and mathematics. The prize will be awarded to students scoring on the Graduate Record Examination at the 90th percentile in chemistry, mathematics, or physics; in the 95th percentile in biology, computer science, or engineering.

Each year the department confers four awards: the Outstanding Graduating Senior in Mathematics Award, the Outstanding Graduating Senior in Computer Science Award, the Outstanding Service to the

Computer Science Program Award, and the Outstanding Graduating Senior in Data Science Award.

Pi Mu Epsilon (PME), the National Mathematics Honor Society, was founded in 1914 at Syracuse University for the purpose of promoting scholarly activity in mathematics among students. The Linfield University Oregon Epsilon chapter was installed in May 2007. New members are elected to the chapter each year from among those students who have

1. a minimum of 20 credits that count toward a major in mathematics,
2. at least a 3.300 GPA in mathematics major courses, and
3. a university GPA of at least 3.000.

Placement in Mathematics Courses

Placement in mathematics courses is based on the students' previous study. During orientation students complete questionnaires regarding their background in mathematics. Based on the results of the questionnaire, students are guided to the correct course in which to begin their study of mathematics at Linfield. The faculty of the Mathematics, Computer Science, and Data Science Department is available for consultation and assistance in the process.

Programs

- Mathematics Major (<http://catalog.linfield.edu/programs-az/arts-sciences/mathematics/mathematics-major/>)
- Mathematics Minor (<http://catalog.linfield.edu/programs-az/arts-sciences/mathematics/mathematics-minor/>)
- Mathematics Education Minor (<http://catalog.linfield.edu/programs-az/arts-sciences/mathematics/mathematics-education-minor/>)
- Data Science Major (<http://catalog.linfield.edu/programs-az/arts-sciences/mathematics/data-science-major/>)
- Data Science Minor (<http://catalog.linfield.edu/programs-az/arts-sciences/mathematics/data-science-minor/>)
- Computer Science Major (<http://catalog.linfield.edu/programs-az/arts-sciences/mathematics/computer-science-major/>)
- Computer Science Minor (<http://catalog.linfield.edu/programs-az/arts-sciences/mathematics/computer-science-minor/>)

For Online and Continuing Education majors, minors, and certificates in the area of computer science, see the Online and Continuing Education (<http://catalog.linfield.edu/programs-az/online-continuing-education/>) section of the catalog.

Courses

A list of the department's infrequently taught courses can be found on the Registrar's webpages.

Mathematics Courses

MATH 105 INTERMEDIATE ALGEBRA (3 credits)

Number systems and their properties, solving linear and quadratic equations, solving systems of equations, polynomials and factoring, graphing linear and quadratic equations, graphing inequalities, exponents and radicals, operations on rational functions. Should not be needed by students with high school algebra II. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: High school algebra I and geometry, or equivalent.

MATH 125 INTRODUCTION TO VOTING THEORY (4 credits)

Study of voting and elections from a mathematical perspective; examination of preferential voting systems with focus on axioms of fairness; weighted voting systems and indices of power; methods of apportionment, paradoxes, and the Electoral College.

Prerequisites: High school algebra I and geometry, or equivalent.

Typically offered: Fall Semester, Odd Years

(QUANTITATIVE REASONING)

MATH 135 MATHEMATICS FOR ELEMENTARY TEACHER I (4 credits)

The mathematics of the elementary school. Problem solving, sets and logic, number and numeration systems, whole number operations and their properties, patterns among natural numbers, the art of guessing, fractions, decimals, ratios and portions, integers, rational and irrational numbers, and the use of calculators.

Prerequisites: MATH 105 or equivalent.

(QUANTITATIVE REASONING)

MATH 136 MATH FOR ELEMENTARY TEACHERS II (4 credits)

A continuation of 135. Collection and treatment of data, concepts of probability, measurement, spatial concepts including one-, two- and three-dimensional shapes, congruence, similarity, and transformations inclusive of integrated classroom technology.

Prerequisites: MATH 135 or instructor consent.

MATH 140 INTRODUCTION TO STATISTICS (3 credits)

An introduction to probability and statistics including methods of summarizing and describing data, basics of probability, distribution of random variables and probability distributions including the normal curve, inferential statistics including hypothesis testing and decision making, linear regression and correlation. Additional topics may include chi-square analysis and analysis of variance.

Prerequisites: MATH 105 or high school algebra I and II and geometry, or equivalent.

(QUANTITATIVE REASONING)

MATH 150 PRECALCULUS (5 credits)

Topics in algebra and trigonometry beyond those covered in the second course in high school algebra. Emphasis on concepts, structures and technical competence. Solutions of algebraic equations and inequalities; functions and graphs; exponential, logarithmic, and trigonometric functions; elementary plane analytic geometry.

Prerequisites: MATH 105 or high school algebra I and II and geometry, or equivalent.

MATH 160 FINITE MATHEMATICS WITH CALCULUS (5 credits)

Review of algebra including equations, inequalities, functions, graphs, logarithms and exponentials. Topics in finite mathematics including matrix algebra and linear programming. Introduction to differential calculus and use in optimization. Applications in business, economics and the social sciences.

Prerequisites: MATH 105 or equivalent.

MATH 161 INTRODUCTION TO FINITE MATHEMATICS (2 credits)

Review of algebra including linear and quadratic equations, inequalities, functions, graphs. Applications in business, economics, and the social and behavioral sciences. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: MATH 105 or consent of instructor.

MATH 162 FINITE MATHEMATICS AND CALCULUS (3 credits)

A continuation of 161, including logarithmic and exponential functions, and topics in finite mathematics including matrix algebra and linear programming. An introduction to differential calculus and its use in optimization. Applications in business, economics and the social and behavioral sciences. Completion of both 161 and 162 is the equivalent of 160. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: MATH 161 or consent of instructor.

MATH 170 CALCULUS I (5 credits)

Differential and integral calculus of real functions of one variable. Differentiation, the chain rule, the mean-value theorem, the fundamental theorem, limits and continuity, curve sketching. Integration by substitution. Application of the derivative and integral to physics and geometry.

Prerequisites: MATH 150 or equivalent.

MATH 175 CALCULUS II (3 credits)

A continuation of Calculus I to include further techniques of integration, Taylor approximations, sequences and series. Plane analytic geometry, parametric equations, including polar form.

Prerequisites: MATH 170 or equivalent with a grade of C- or better.

MATH 198 SPECIAL TOPICS: JAN TERM TRAVEL (4 credits)

Topics vary according to faculty availability and interest. Past topics have included Traversing the Eulerian Trail, and Capital Ideas: Mathematics and Culture in Dynastic China and Japan. Offered only as student interest and university resources permit. May be repeated for credit with different topics.

Prerequisites: IDST 098 previous fall.

Typically offered: January Term

MATH 200 VECTOR CALCULUS (5 credits)

Functions of several variables; differentiability and continuity; arc length and differential geometry; Taylor's formula; extrema and Lagrange multipliers; multiple integration, line and surface integrals; the theorems of Green, Gauss and Stokes.

Prerequisites: MATH 175 or equivalent.

MATH 210 ORDINARY DIFFERENTIAL EQUATIONS (4 credits)

First-order equations, including separation of variables and integrating factors; second-order linear equations, including nonhomogeneous techniques, Laplace transforms and power series methods; linear systems, including eigenvalue methods and matrix exponentials; applications to mechanics, physics, chemistry, biology and economics.

Prerequisites: MATH 175 or equivalent.

Typically offered: Spring Semester

(QUANTITATIVE REASONING)

MATH 220 INTRODUCTION TO PROOFS (3 credits)

Fundamental concepts in abstract mathematics with an emphasis on learning to write mathematical proofs. Topics include logic, sets, relations, functions, proof by contradiction, proof by contrapositive, and mathematical induction.

Prerequisites: MATH 170 or equivalent with a grade of C- or better.

Typically offered: January Term

MATH 230 DISCRETE MATHEMATICS (4 credits)

Topics in the general area of discrete mathematical structures including sets, logic, relations, functions, induction, matrices, basic enumeration, graphs, and Boolean algebra.

Prerequisites: MATH 170 or equivalent with a grade of C- or better.

Typically offered: Fall Semester

MATH 250 LINEAR ALGEBRA (4 credits)

Matrix theory and linear algebra, including linear transformations and their matrices, systems of linear equations, determinants, eigenvalues, vector spaces, orthogonal matrices and bases, and reduced and canonical forms. Applications may include image compression, dynamical systems, stochastic matrices and Markov chains.

Prerequisites: MATH 170 or equivalent with a grade of C- or better.

MATH 280 MATHEMATICAL MODELING EXPERIENCE (1 credit)

Participation in the Mathematical Contest in Modeling sponsored by the Consortium for Mathematics and its Applications. Experience solving real world problems using mathematical methods. Formal presentation of project results. May be repeated for credit.

Prerequisites: Consent of instructor.

Typically offered: Spring Semester

MATH 290 HISTORY OF MATHEMATICS (3 credits)

Topics in the development of mathematics from ancient times to present.

Prerequisites: MATH 175 and INQS 125 or instructor consent.

Typically offered: Spring Semester, Even Years

MATH 298 SPECIAL TOPICS: JAN TERM TRAVEL (4 credits)

Topics vary according to faculty availability and interest. Past topics have included Traversing the Eulerian Trail, and Capital Ideas: Mathematics and Culture in Dynastic China and Japan. Offered only as student interest and university resources permit. May be repeated for credit with different topics.

Prerequisites: IDST 098 previous fall.

Typically offered: January Term

MATH 310 NONLINEAR ODE'S & DYNAMIC SYSTEMS (3 credits)

Nonlinear differential equations from a dynamical systems approach.

Scalar autonomous equations; elementary bifurcations; linear systems and canonical forms; planar autonomous systems; stability near equilibria including Liapunov functions; periodic orbits and the Poincare-Bendixson theorem; Lorenz equations, chaos and strange attractors; one-dimensional maps including the logistical map.

Prerequisites: MATH 200 and MATH 210 or instructor consent.

Typically offered: Fall Semester, Even Years

(QUANTITATIVE REASONING)

MATH 320 HIGHER GEOMETRY (4 credits)

Modern exploration of geometries as the study of objects and functions that remain unchanged under allowable transformations. Mobius transformations and their properties; Euclidean, elliptic, and hyperbolic geometries; the geometry and topology of surfaces, including the Gauss-Bonnet Theorem; 3-manifolds and the shape of the universe; connections to topology and group theory will be made, though no background from those areas will be required for this class.

Prerequisites: MATH 175 and at least one of MATH 220, MATH 230, or MATH 250

Typically offered: Fall Semester, Even Years

MATH 330 COMBINATORICS (3 credits)

Combinatorial theory with focus on techniques of enumeration. Topics include generating functions, recurrence relations, inclusion-exclusion, pigeonhole principle. Advanced topics selected from posets, lattices, Polya counting, difference sequences, Stirling numbers, and Catalan numbers.

Prerequisites: MATH 175 and at least one of MATH 220, MATH 230, or MATH 250.

Typically offered: Spring Semester, Odd Years

MATH 340 PROBABILITY AND STATISTICS I (4 credits)

Discrete and continuous random variables; descriptive statistics of a single random variable; the Central Limit Theorem; applications of confidence intervals and hypothesis testing; linear regression.

Prerequisites: MATH 175.

Typically offered: Fall Semester

(QUANTITATIVE REASONING)

MATH 350 NUMBER THEORY (3 credits)

Properties of the integers. Divisibility, prime numbers, congruence. Chinese Remainder Theorem, Wilson's Theorem, Euler's Theorem. Emphasis on writing proofs in the context of number theory; mathematical induction.

Prerequisites: MATH 220, MATH 230, or MATH 250.

Typically offered: Fall Semester, Even Years

MATH 365 GAME THEORY (3 credits)

The mathematics of economic game theory. Two-person matrix games and their solutions. The Minimax Theorem, linear programming and the simplex method, Nash equilibria. Topics from non-cooperative and cooperative game theory.

Prerequisites: MATH 175 and MATH 250.

Typically offered: Spring Semester, Odd Years

(QUANTITATIVE REASONING)

MATH 370 ELEMENTARY ANALYSIS (4 credits)

Fundamental proof-writing techniques emphasizing analysis of real-valued functions; sequences including Cauchy sequences; limits and continuity including uniform continuity; differentiation, the mean value theorem and Taylor's Theorem; the Riemann integral and the fundamental theorem of calculus.

Prerequisites: MATH 175. MATH 220 or MATH 230 recommended.

Typically offered: Fall Semester, Annually

MATH 380 NUMERICAL ANALYSIS (4 credits)

Numerical analysis involving mathematical and statistical methods, use of interactive mathematical software to solve such problems. Topics include: numerical solution of non-linear equations, numerical solution of systems of equations, numerical differentiation and integration, numerical solution of ordinary differential equations, interpolation, curve fitting, analysis of errors.

Prerequisites: MATH 200. MATH 250 (may be taken concurrently).

Typically offered: Spring Semester, Odd Years

MATH 398 SPECIAL TOPICS: JAN TERM TRAVEL (4 credits)

Topics vary according to faculty availability and interest. Past topics have included Traversing the Eulerian Trail, and Capital Ideas: Mathematics and Culture in Dynastic China and Japan. Offered only as student interest and university resources permit. May be repeated for credit with different topics.

Prerequisites: IDST 098 previous fall.

Typically offered: January Term

MATH 400 TOPICS IN MATHEMATICS (1-5 credits)

Selected topics not regularly offered at Linfield.

MATH 410 PARTIAL DIFFERENTIAL EQUATIONS (3 credits)

Fourier series and the methods of separation of variables; Sturm-Liouville problems; Green's functions; the method of characteristics; Laplace, heat and wave equations, and selected applications.

Prerequisites: MATH 200 and MATH 210.

Typically offered: Fall Semester, Odd Years

MATH 420 TOPOLOGY (3 credits)

Basic topics in point set topology. Product, quotient and subspace topologies; metric spaces; closed sets and limit points; connectedness; compactness; the separation axioms; introduction to fundamental group and covering spaces.

Prerequisites: MATH 200 and at least one of MATH 220, MATH 230, or MATH 250. MATH 370 strongly recommended.

Typically offered: Fall Semester, Odd Years

MATH 430 GRAPH THEORY (3 credits)

Topics in graph theory including trees, bipartite graphs, Eulerian and Hamiltonian graphs, matchings, connectivity, coloring, planar graphs. Advanced topics selected from Ramsey theory, pebbling, competitive coloring, and matroids.

Prerequisites: MATH 220, MATH 230, or MATH 250.

Typically offered: Spring Semester, Even Years

MATH 440 PROBABILITY & STATISTICS II (3 credits)

Multivariate probability distributions; functions of random variables; point estimators; maximum likelihood estimators; theory of hypothesis testing and power; method of least squares.

Prerequisites: MATH 200 and MATH 340.

Typically offered: Spring Semester, Even Years

MATH 450 ABSTRACT ALGEBRA (4 credits)

Basic algebraic structures; groups, rings, and fields. Cosets, normal subgroups, factor groups, ideals, factor rings, polynomial rings. Homomorphisms and isomorphisms.

Prerequisites: MATH 220, MATH 230, or MATH 250.

Typically offered: Spring Semester, Odd Years

MATH 460 COMPLEX ANALYSIS (4 credits)

Complex numbers and functions; the complex derivative; complex integration; Taylor and Laurent series; residue theory; conformal mapping. Selected applications.

Prerequisites: MATH 200 and MATH 370.

Typically offered: Spring Semester, Odd Years

MATH 470 REAL ANALYSIS (4 credits)

Infinite Series of Real Numbers; Infinite Series of Functions including Power Series and Analytic Functions; Topology of Euclidean Spaces; Differentiability on \mathbb{R}^n ; Riemann Integration on \mathbb{R}^n ; Measurable sets and functions; Introduction to Lebesgue integration and convergence theorems.

Prerequisites: MATH 200, MATH 250 and MATH 370.

Typically offered: Spring Semester, Even Years

MATH 480 INDEPENDENT STUDY (1-5 credits)

Study of selected topics under an instructor's guidance. For advanced mathematics majors with a high degree of self-reliance. Periodic written and oral reports and, in most cases, a comprehensive final paper.

MATH 485 SENIOR SEMINAR (3 credits)

Department capstone course. Examination of the nature of mathematics and its role within the liberal arts. Focus on reading current mathematics, writing a survey article, and presenting results. (Listed as DATA 485 and MATH 485)

Prerequisites: MATH 370 and senior standing, or consent of instructor.

Typically offered: Spring Semester

(MAJOR WRITING INTENSIVE)

MATH 498 SPECIAL TOPICS: JAN TERM TRAVEL (4 credits)

Topics vary according to faculty availability and interest. Past topics have included Traversing the Eulerian Trail, and Capital Ideas: Mathematics and Culture in Dynastic China and Japan. Offered only as student interest and university resources permit. May be repeated for credit with different topics.

Prerequisites: IDST 098 previous fall.

Typically offered: January Term

Data Science Courses**DATA 125 SURVEY OF DATA SCIENCE (4 credits)**

Introduction to emerging field of data science. Topics include necessary math and statistics principles, introduction to computer tools and software for data analytics, overview of algorithms.

Typically offered: Fall Semester, Annually

(QUANTITATIVE REASONING)

DATA 135 FAIRNESS AND RESPONSIBILITY IN DATA SCI (4 credits)

Discussion and readings of ethical issues in data science including how data is collected and used in decision-making, and how algorithms are impacting people's lives. Major themes will include issues of fairness, bias, privacy, and transparency.

Typically offered: Spring Semester, Even Years

(ULTIMATE QUESTIONS)

DATA 225 INTRODUCTION TO VISUALIZATIONS (4 credits)

Creating data visualizations using Excel, R, and Python. Discussions of different types of visual aids. Methods to improve common ineffective visualizations.

DATA 445 MACHINE LEARNING (4 credits)

Basic theory and practice of machine learning algorithms. Topics include regression, classification, supervised and unsupervised learning, deep learning, and other statistical modeling tools. Includes programming projects and in-class labs.

Prerequisites: DATA 125, MATH 250, MATH 140 or 340, COMP 260.

Typically offered: Spring Semester, Annually

(QUANTITATIVE REASONING)

DATA 485 SENIOR SEMINAR (3 credits)

Department capstone course. Examination of the nature of mathematics and its role within liberal arts. Focus on reading current mathematics, writing survey article, and presenting results. (Listed as DATA 485 and MATH 485)

(MAJOR WRITING INTENSIVE)

DATA 488 DATA SCIENCE CONSULTING (3 credits)

Applied data science in team setting, project based. Training in data science consulting; assisting in collaboration with faculty and/or clients on pre-determined projects.

Prerequisites: DATA 225, DATA 445.

DATA 490 CAPSTONE PROJECT (4 credits)

Research or software application development on topic within discipline of interest. (Listed as COMP 490 and DATA 490)

Computer Science Courses**COMP 101 FUNDAMENTALS OF INFORMATION SYSTEMS TEC (3 credits)**

Broad overview of computer science. Topics include basic concepts in hardware, operating systems and networks, algorithmic problem solving, introduction to the object-oriented paradigm, and an overview of the social context of computing. No background in computer science is assumed or expected. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

COMP 120 MICROCOMPUTER APPLICATIONS (3 credits)

Introduction to useful problem solving, using current software on PC-compatibles and Apple Macintoshes. Major operating systems, word processing, file creation, database management, data communications, electronic spreadsheets, form letters, idea processing, business graphics, sorting, searching, printing, and integrated software systems. Not for credit toward Computer Science major or minor. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Total Course fees: \$50.00

COMP 121 INTRODUCTION TO WEB DESIGN (4 credits)

Introduces web page creation using markup and interactive webpage languages utilizing industry standard frameworks. Introduces web server management. Discussion of history and development of the Internet and Web. Includes project-based laboratory work.

Total Course fees: \$30.00

Typically offered: Fall Semester

COMP 131 COMPUTERS IN MODERN SOCIETY (4 credits)

Impact of computers on present and future society. Benefits and problems of computer technology. History of computing and computers. Ethical and legal basis for privacy protection; technological strategies for privacy protection; freedom of expression in cyberspace; international and intercultural implications. Information security and crime. Social, ethical, political and technological implications and effects of computers in the modern world.

Total Course fees: \$30.00

Typically offered: Spring Semester

(INDIVID/SYSTEMS/SOCIETIES)

COMP 152 PROGRAMMING & OBJECT STRUCTURES (4 credits)

Concepts of object-oriented and procedural software engineering methodologies in data definition and measurement, abstract data type construction and use in developing screen editors, reports and other IS applications. Programming in visual development environment that incorporates event driven and object-oriented design. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Total Course fees: \$30.00

Prerequisites: COMP 101 must be completed or taken concurrently.

COMP 153 HUMAN COMPUTER INTERACTION (3 credits)

Principles and methods involved in building effective user interfaces. Examination of human factors associated with information systems. User-centered methodologies in the design, development, evaluation, and deployment of IT applications and systems. Focus will be on methods and tools for developing effective user interfaces, evaluation methods such as the conduct of usability and heuristic evaluations, design of appropriate interface elements including the design of menus and other interaction styles. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: COMP 152.

COMP 160 BEG. PROGRAMMING AND PROBLEM-SOLVING (4 credits)

Introduces algorithmic problem-solving techniques and the implementation of solutions in the Python programming language. This course assumes no previous programming experience and is appropriate for all students who want to write programs. It is typically the first course taken by students interested in majoring in Computer Science. Includes project-based laboratory work.

Total Course fees: \$30.00

Prerequisites: COMP 160L required co-requisite.

Typically offered: Fall Semester, Annually

(QUANTITATIVE REASONING)

COMP 161 BEGINNING PROGRAMMING: OBJECTS (4 credits)

Extends the introduction of programming begun in COMP 160 to include object-oriented programming and basic data structures--linked lists, stacks and queues--and related algorithms. Lectures and mandatory one hour lab session per week.

Total Course fees: \$30.00

Prerequisites: COMP 160, or instructor consent. COMP 161L required co-requisite.

Typically offered: Spring Semester

(QUANTITATIVE REASONING)

COMP 250 DATABASE PROGRAM DEVELOPMENT (3 credits)

Application program development in a database environment using a host language. Data structures, file organizations, models of data storage devices, data administration and data analysis, design and implementation. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: COMP 152 as a pre- or co-requisite.

COMP 252 SYSTEMS ADMINISTRATION AND NETWORKING CONCEPTS (3 credits)

Installation, administration and maintenance of various modern operating systems widely-used in academic, industrial and research environments. Communications concepts, network architectures, data communication software and hardware. Local Area Networks and Wide Area Networks, network protocol suites. Internetworking and routing, network management, and distributed information systems. Extensive hands-on experience based on the management of a fully functioning computer network systems. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Total Course fees: \$30.00

Prerequisites: COMP 101 must be completed or may be taken concurrently.

Typically offered: Fall Semester

COMP 260 DATABASE MANAGEMENT SYSTEMS (4 credits)

Information systems design and implementation within a database management system environment. Topics include conceptual, logical, and physical data models and modeling tools; mapping conceptual schema to relational schema, entity and referential integrity, relational algebra and relational calculus. Database query languages [Structured Query Language (SQL)]. Relational database design, transaction processing, and physical database design (storage and file structures). Database implementation, including use interface and reports. Lectures and mandatory one hour lab session per week.

Total Course fees: \$30.00

Typically offered: Fall Semester

COMP 262 DATA STRUCTURES AND ALGORITHMS (4 credits)

Adds data abstraction, intermediate data types and related algorithms to the beginning programming techniques learned in COMP 161. Lectures and mandatory one hour lab session per week.

Total Course fees: \$30.00

Prerequisites: COMP 161. MATH 230 completed or concurrent. COMP 262L required co-requisite.

Typically offered: Fall Semester

COMP 280 CLOUD COMPUTING (4 credits)

Cloud application challenges and alternatives. Basic architecture: Rest and Serverless APIs, Javascript, RDBS and NoSQL databases. Performance and Cost: Network bandwidth and latency, pagination, scanning versus querying. Security: Cross Origin Resource Sharing (CORS). Design and creation of a real-world cloud application as part of a small group. Lectures and mandatory one-hour lab session per week.

Total Course fees: \$30.00

Total Course fees: \$30.00

Prerequisites: COMP 161, COMP 260

Typically offered: Spring Semester, Alternate Years

COMP 291 PROJECT MANAGEMENT I: FUNDAMENTALS (3 credits)

Exploration of the purpose of project management, the tasks of project management, and the core managerial skills required. Study of how to leverage and use available resources to develop a project plan and to make and implement decisions. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

COMP 301 DIGITAL FORENSICS (3 credits)

Comprehensive understanding of digital forensics and investigation tools and techniques in acquisition, recovery, documentation, and analysis of information contained within and created with computer systems and computing devices. Digital evidence methods and standards, techniques and standards for preservation of data, application forensics, web forensics, network forensics, mobile device forensics, and information security audit. Labs and projects consist of hands-on exercises that reinforce the subject matter. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Typically offered: Spring Semester

COMP 302 SOFTWARE ENGINEERING (3 credits)

Analysis, design, implementation, and testing of a medium-scale software system as a member of a project team. Significant real-world group projects covering all the phases of software development life cycle using high-level automated analysis and design tools. Experience with other important skills such as fact-finding, communications, and project management. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Total Course fees: \$30.00

Prerequisites: COMP 250.

Typically offered: Fall, Spring, and Summer Terms

(MAJOR WRITING INTENSIVE)

COMP 305 SOFTWARE ENGINEERING (4 credits)

Analysis, design, implementation, and testing of a medium-scale software system as a member of a project team. Significant real-world group projects covering all the phases of software of development life cycle using high-level automated analysis and design tools. Experience with other important skills such as fact-finding, communications, and project management. Lectures and mandatory lab session per week.

Total Course fees: \$30.00

Prerequisites: COMP 161. COMP 305L required co-requisite. COMP 260.

Typically offered: Spring Semester

COMP 310 WEB SYSTEMS AND TECHNOLOGIES (3 credits)

Modern applications software in business environments. Topics include: Enterprise web application development and security, web service, and XML in the enterprise. Hands-on experience using current technology to build business-to-business (B2B) and business-to-computer (B2C) applications. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: COMP 250.

COMP 330 OPERATING SYSTEMS AND NETWORKING (3 credits)

Operating systems design and implementation. Topics include overview of components of an operating system, mutual exclusion and synchronization, implementation of processes, scheduling algorithms, memory management, and file systems. Net-centric computing, network architectures; issues associated with distributed computing. Lectures and mandatory one hour lab session per week.

Total Course fees: \$30.00

Prerequisites: COMP 161.

Typically offered: Spring Semester, Odd Years

COMP 370 ADVANCED TOPICS IN ALG, COMPLEX, INTELL (4 credits)

Topics may include: distributed algorithms, complexity classes P and NP, automata theory, algorithmic analysis, cryptographic, geometric or parallel algorithms, compression and decompression, search and constraint satisfaction, knowledge representation and reasoning, agents, natural language processing, machine learning and neural networks, artificial intelligence planning systems and robotics. Lectures and mandatory one hour lab session per week.

Total Course fees: \$30.00

Prerequisites: COMP 160. COMP 370L required co-requisite.

Typically offered: Fall Semester

COMP 375 MOBILE DEVELOPMENT (3 credits)

Fundamental principles and techniques of interactive application design as they are implemented on an industry standard platform. Topics: emerging technologies, mobile & web programming frameworks, data-driven applications, modern GUI tools, input/output modalities, rapid prototyping, and user experience. Extensive hands-on programming experience via platform-specific APIs. Lecture/discussion.

Total Course fees: \$30.00

Prerequisites: COMP 161.

Typically offered: Spring Semester, Odd Years

COMP 377 COMPUTER ARCHITECTURE (4 credits)

Concepts of the fundamental logical organization of a computer (its parts and their relationship) and how it actually works; exposure to a central processor's native language, and to system concepts. Topics in computer hardware, architectures, and digital logic. Lectures and mandatory one hour lab session per week.

Total Course fees: \$30.00

Prerequisites: COMP 160.

Typically offered: Spring Semester, Even Years

COMP 382 MANAGEMENT INFORMATION SYSTEMS (3 credits)

Real world applications of information systems concepts. The value and uses of information systems for business operation, management decision making, and strategic advantage. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Total Course fees: \$30.00

Prerequisites: MATH 140 and MATH 160.

COMP 392 PROJECT MANAGEMENT II: MANAGEMENT SKILLS, ASSESSMENT AND DEVELOPMENT (3 credits)

Exploration of project management functions and skills, analysis of recurrent problems encountered, and consideration of factors that decision-makers need to understand to be successful. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: COMP 291.

COMP 393 PROJECT MANAGEMENT III: QUALITY MANAGEMENT FUNDAMENTALS (3 credits)

Systematic introduction to the art and science of Quality Management that explores the philosophy, theory, principles, concepts, methods, processes, techniques, and tools of Quality Management and TQM, and how to apply them to large and complex projects. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: COMP 392.

(MAJOR WRITING INTENSIVE)

COMP 400 APPLIED SOFTWARE DEVELOPMENT PROJECT (3 credits)

Comprehensive systems development project. Team approach to analyze, design, and document realistic systems of moderate complexity. Project management methods, scheduling and control, formal presentations, and group dynamics in solving systems problems. Development of a database. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Total Course fees: \$30.00

Prerequisites: COMP 302 (may be taken concurrently).

COMP 404 OPERATIONS MANAGEMENT (3 credits)

Methods for managing production and distribution of manufacturing and service systems. Capacity determination, operating systems design, operating procedures analysis, and control systems development. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: MATH 140 and MATH 160.

COMP 405 PLATFORM-BASED SOFTWARE DEVELOPMENT (3 credits)

Lectures and mandatory one hour lab session per week. Design and development of software applications that reside on specific platforms. The course focuses on integrated software development environment in which application development methodologies and constraints for web platforms, mobile platforms and game platforms. Lecture and mandatory one hour lab session per week.

Total Course fees: \$30.00

Prerequisites: COMP 260. COMP 405L required as co-requisite.

Typically offered: Spring Semester, Even Years

COMP 430 COMPUTER SECURITY (4 credits)

Lectures and mandatory one hour lab session per week. Network security concepts and methodologies. Topics include: security concepts and services, physical, operational, and organizational security, the role of people in systems security compliance and operational security; threats and vulnerabilities; network security. Access control and identity management; cryptography. Labs and projects will focus on techniques and tools for vulnerability detection and defense. Lecture and mandatory one hour lab session per week.

Total Course fees: \$30.00

Prerequisites: COMP 161 or COMP 252 or instructor consent. COMP 430L required concurrently.

Typically offered: Fall Semester

COMP 431 ADVANCED NETWORK COMMUNICATION & SECURITY (4 credits)

Advanced concepts and applications of network communication and security. Topics include: client-server communications, web services and applications, network systems discovery, advanced access control, trade-off between network usability and security, configuration and hardening recommendations and strategies, monitoring, intrusion detection, countermeasures, and incident response. Emphasis on developing, deploying, and maintaining a secure network communication infrastructure. Lecture and mandatory one hour lab session per week.

Optional weekend field trip event over spring break.

Total Course fees: \$30.00

Prerequisites: COMP 430 or consent of instructor.

Typically offered: Spring Semester

COMP 450 DATABASE ADMINISTRATION (3 credits)

Database administration, technology, selection of database management systems. Practicum in data modeling and system development in a database environment. Trends in data management. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: COMP 250.

(MAJOR WRITING INTENSIVE)

COMP 480 INDEPENDENT STUDY (1-3 credits)

Program of directed tutorial reading on some topic or problem within the discipline relating to the special interests of the student and supervised by a departmental faculty member.

Total Course fees: \$30.00

COMP 484 OPERATIONS RESEARCH (3 credits)

Quantitative techniques for managerial decision-making. Linear programming, markov analysis, queuing models, network analysis and simulation. OFFERED THROUGH ONLINE AND CONTINUING EDUCATION (OCE) ONLY.

Prerequisites: COMP 404.

COMP 485 ADVANCED TOPICS IN COMPUTER SCIENCE (3 credits)

Topics of current interest in computer science. May include: advanced software engineering, human computer interaction, advanced networking and systems administration, advanced database systems, computer animation and simulation, finite automata and languages, and intelligent systems. Prerequisites: varies with topic.

Total Course fees: \$30.00

Typically offered: Spring Semester

COMP 487 SOFTWARE ENGINEERING INTERNSHIP (1-3 credits)

Practical on-site work experience in a computer-intensive operation with academic oversight. Experience with a variety of programming languages, operating systems, applications, and machines.

Prerequisites: 20 credits in Computer Science.

(EXPERIENTIAL LEARNING)

COMP 490 CAPSTONE PROJECT (4 credits)

Research or software application development on some topic or problem within the discipline relating to the special interests of the student.

(Listed as COMP 490 and DATA 490)

Total Course fees: \$30.00

Typically offered: Fall Semester

(MAJOR WRITING INTENSIVE)