

Department of Mathematics and Computer Science

Faculty

Ethan Bolker, Professor and Chair; Professors Bernice Auslander, Alfonso Azpeitia, James Byrnes, Patricia Davidson, Matthew Gaffney, Hans Herda, Herbert Kamowitz, Joan Lukas, Robert Morris, Stephen Parrott, Geza Schay, Robert Seeley, Dan Simovici; Associate Professors William Campbell, Daniel Comenetz, Richard H Eckhouse Jr, Peter Fejer, Colin Godfrey, Michael Greeley, Linda Kime, George Lukas, John Lutts, Some Mukherjee, Kenneth Newman, Elizabeth O'Neil, Patrick O'Neil, Richard Tenney, Richard Truesdell, Dennis Wortman; Part-Time Instructor Joseph Russell; Part-Time Lecturer Wen Yuan Kong.

The Department

The Department of Mathematics and Computer Science offers programs leading to a BA or BS in applied mathematics, computer science, or pure mathematics. Both matriculated and non-matriculated students may earn a major certificate (equivalent to a major in computer science) or a minor certificate (oriented to applications) in computer science. At the graduate level, the department offers the master's degree in computer science.

The department also offers introductory courses to prepare undergraduate students for programs in premedical studies, management, the social sciences, and the natural sciences.

Requirements and Recommendations

Preparatory Work

Any student who intends to take a mathematics course at or below the level of Math 140 (Calculus I) or a Computer Science course at or below CS 110 (An Introduction to Computer Programming) must furnish proof to the department that he or she is prepared for that course. This proof must be either:

- A. a suitable score on the math placement exam or
- B. evidence indicating that he or she has successfully completed the prerequisites for the course. Only courses taken at UMass Boston can be considered.

Note in particular that successful completion of Math 110 does not qualify one to take either Math 130 or CS 110. To enter either of these courses one must have a suitable placement test score. (The placement test for CS 110 is waived for students who have completed Math 140, Calculus I at UMass Boston or its equivalent elsewhere.)

Majors

At present, the Department of Mathematics and Computer Science offers three different major programs: one in pure mathematics, one in applied mathematics and one in computer science. The requirements of these majors are listed below. Students should note, however, that as this publication went to press the department was in the process of revising the pure and applied mathematics majors. Thus, future major requirements may differ substantially from those listed here. It is therefore essential that each student obtain up-to-date information from faculty advisors and departmental brochures.

- I. To earn a BA degree in pure mathematics a student must take:
 - A. Math 140, 141, 240, 260, 310 or 320, 360, and 450,
 - B. At least four math courses beyond Math 260 (other than those counted in (A) above,
 - C. Physics 113 (lab optional).
- II. To earn a BA degree in applied mathematics a student must take:
 - A. CS 110, Math 140, Math 141, Math 240, Math 260, and Math 450
 - B. Physics 113 (lab optional)
 - C. Six courses chosen from among those named below, chosen so as to include at least one from Group 1 and at least four from Group 2.

Group 1: CS 310, Math 345, Math 425, Math 472

Group 2: CS 240, CS 310, CS 320, Math 310, Math 345, Math 346, Math 350, Math 354, Math 358, Math 425

To earn a BA degree in computer science a student must take:

- A. Math 140, 141, and 260
- B. CS 110, CS 210, CS 240, CS 241, CS 260, CS 310, CS 320
- C. CS 420, one theoretical elective, and two applied electives, chosen from lists maintained and periodically revised by the department. (One of the applied electives must be at the 400 level)

Students pursuing a major in the Department of Mathematics and Computer Science must take a minimum of four upper division courses in their major at UMass Boston rather than at another institution. Each is strongly advised to seek advice pertinent to his or her situation from an advisor in the department. Majors who wish to take courses in Management Science and Information Systems (in the College of Management) should consult the department before enrolling.

The Bachelor of Science Degree

To earn a BS degree in any of the three areas a student must demonstrate a broad knowledge of the sciences in addition to the major requirements above by taking six courses in the sciences outside the Department. Those courses must be appropriate for majors in those departments offering the courses, and must include Physics 113 and 114. One laboratory course is required. Within the Department of Mathematics and Computer Science, CS 440 counts as a laboratory course.

Certificates in Computer Science

To earn a major certificate in computer science a student must fulfill all the requirements for the BA degree in computer science listed above. To earn a minor certificate a student must take CS 110, CS 210, CS 240, CS 310, Math 140; either CS 260 or a computer science elective; and one applications course approved by the department. Students interested in these programs should consult the computer science information brochure available in the department (see also the description in this publication under "Computer Science Programs").

Juan Carlos Merlo Prize

This prize is awarded annually to a graduating mathematics student for outstanding achievement. The prize honors the memory of Professor Juan Carlos Merlo, a distinguished teacher and scholar who died in 1974 while in the service of the University of Massachusetts Boston.

Taffee Tanimoto Award for Service

This prize is awarded annually to a graduating senior who has particularly distinguished himself or herself by being of service to classmates and the Department. The prize honors Professor Taffee Tanimoto, who founded the Department of Mathematics and Computer Science at UMass/Boston in 1965 and was its chair for 11 years.

Transfer Credit Policy

Students receiving transfer credit for mathematics courses taken at other institutions who wish to take more mathematics at UMass Boston at a level below Math 141 may find that their placement test scores indicate that they must repeat courses for which they already have credit. If they do, they will forfeit the transfer credit. An alternative which entails no loss of credit is to audit the UMass Boston course as preparation for retaking the placement exam.

Transfer credit for AP calculus or more advanced work, or through CLEP is handled by the Admissions Office in cooperation with the department.

Department of Mathematics and Computer Science

Preparation in Fundamental Skills

The CAS Office of Academic Support Programs offers the two-credit courses AS 033 and AS 034 to prepare students for Math 110 and to provide instruction in elementary mathematics. For details, consult the "Academic Skills" section of this publication.

Courses

Math 110

Basic Algebra

For students with a weak math background who want to develop skills for further work in mathematics or science courses. Covers basic high school mathematics. Topics include: multiplying and factoring polynomials, linear equations and straight lines, fractional exponents and radicals, ratios of polynomials, quadratics, parabolas, systems of simultaneous linear equations, and word problems. Generally limited to students with less than 3 years of high school math preparation.

Note: No student receives graduation credits for Math 110 if it is taken after successful completion of any higher math course.

Prerequisite: A suitable score on the mathematics diagnostic test only.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Math 114

College Algebra

This course covers linear and quadratic functions; systems of equations; graphical representations of data; expressions involving exponents and scientific notation; estimation, including linear approximations and orders of magnitude. It gives students some acquaintance with higher order functions, including rational and exponential functions. The course is data driven and computer-based; it focuses on mathematics, from the perspectives of first the social sciences and then from the physical and life science perspective.

Note: Students may not receive credit for both Math 110 and 114.

Prerequisite: A suitable score on the mathematics diagnostic test A.

3 Lab/Lect Hrs; 3 credits.

Ms Kime, Ms Davidson, Mr Lutts

Math 124

Applied Algebra

Linear functions, quadratic functions, and exponential and logarithmic functions. The emphasis in this course is on graphing, applications and mathematical modeling.

Note: This course and Math 129 or 130 may not both be taken for credit without the explicit permission of the department. (Students may take Math 129 or 130 after 124 only with departmental permission, and then only for two credits. No student may take this course for credit after successful completion of Math 129, or Math 130, or a higher math course.) Students who wish eventually to take Math 140 are advised not to take this course. Should such a student's placement test score place him or her in this course, he or she should consult the department before registering. While open to all students not excluded by the above, the course is especially designed to be of service to those who major in biology or the more quantitatively-oriented social sciences.

Prerequisite: A suitable score on the mathematics diagnostic test or, if necessary, Math 110.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Math 125

Introductory Statistics

Topics include introductory statistics, covering descriptive statistics; introductory probability sufficient to enable development of inferential statistics; and inferential statistics.

Note: No student receives graduation credits for Math 125 if it is taken after successful completion of Math 345.

Not open to mathematics or science majors, except in nursing and geography.

Prerequisite: A suitable score on the mathematics diagnostic test or Math 110.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Math 129

Pre-Calculus for Management and Social Science Students

This course teaches the algebraic and conceptual skills students need to master before they are ready for Math 134 or Math 135. It first reviews basic algebraic skills. The major part of the course then involves the application of linear, quadratic, and exponential models to problems in management and economics.

Note: Students intending to take Calculus I and II (Math 140 and 141) should take Math 130 instead of Math 129. Students who have successfully completed Math 129 may not subsequently take Math 124 for credit. Students may take Math 130 after Math 129 only with the explicit permission of the department, and then only for two credits. Students who have taken Math 124 may take this course only with departmental permission, and then only for two credits.

Prerequisite: A suitable score on the mathematics diagnostic test.

3 Lect Hrs., 3 Credits

Ms Davidson

Math 130

Precalculus

Preparation for first year calculus. Covers symmetry, graphs, functions, lines, parabolas and max-min problems, exponential and logarithm functions, exponential growth, semilog graphing, and the trigonometric functions and their inverses. Qualified students should enter Math 140 without taking this course.

Note: No student receives graduation credits for Math 130 if it is taken after successful completion of any higher math course. Students who have successfully completed Math 130 may not subsequently take Math 124 or Math 129 for credit. Students may take Math 130 after Math 124 or Math 129 only with explicit permission of the department, and then only for two credits.

Prerequisite: A suitable score on the mathematics diagnostic test only. Successful completion of Math 110 is not enough.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

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Math 134 **Managerial Algebra and Calculus**

This course is designed to provide students with mathematical literacy through mastery of basic algebra and basic calculus. Topics include functions, graphs, absolute value, linear equations, inequalities, systems of linear equations and inequalities, polynomials, exponential and logarithmic functions, limits, continuity, derivatives, summation of series, and integration. Applications will be made to managerial situations throughout the course. Generally, for CM students only. Students may not receive graduation credit for both Math 134 and Math 135. Students may take Math 140 after Math 134 only with explicit permission of the department, and then only for two credits.

Prerequisite: A suitable score on the mathematics diagnostic test or completion of Math 129.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Math 135 **Survey of Calculus**

Calculus developed intuitively and applied to problems in biology, economics, psychology, and geometry. A course for non-physical science and non-math majors. Suitable for some pre-medical programs.

Note: No student receives graduation credit for Math 135 if it is taken after successful completion of Math 134 or 140 or a higher math course. Students may take Math 134 or Math 140 after 135 only with explicit permission of the Math Department, and then only for two credits. (Course offered in the spring only.)

Prerequisite: Math 129 or 130, or a suitable score on the mathematics diagnostic test

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Math 140 **Calculus I**

The first in the sequence of calculus courses for science and math majors. Starts with the basic concepts of functions and limits. Topics covered include: derivatives and their applications, definite and indefinite integrals with applications to geometric and physical problems, and discussion of algebraic and transcendental functions.

Note: A student who has received credit for either Math 134 or Math 135 may not take Math 140 for credit without the explicit permission of the department and then only for two credits.

Prerequisite: A suitable score on the mathematics diagnostic test or Math 130.

Distribution Area: Mathematics and Computer Languages.

4 Lect Hrs, 4 Credits

Math 141 **Calculus II**

Continuation of Math 140. Topics include transcendental functions, techniques of integration, applications of the integral, improper integrals, L'Hospital's rule, sequences, and series. Please note: Because Math 141 is the second part of the integrated calculus sequence, it should be taken as soon as possible after Math 140.

Prerequisite: Math 140 or equivalent.

Distribution Area: Mathematics and Computer Languages.

4 Lect Hrs, 4 Credits

Math 240 **Calculus III**

Calculus of functions of several variables. Topics include: partial derivatives, transformations, the derivative as a matrix, chain rule, directional derivatives, gradients, second derivatives; and multiple integrals, substitution rule, and Jacobians. Please note: Because Math 240 is the final part of a three-semester calculus sequence, it should be taken as soon as possible after Math 141.

Prerequisite: Math 141 is required; Phys 114 is recommended.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Math 260 **Linear Algebra I**

Elementary theory of vector spaces. Topics include linear independence, bases, dimension, linear maps and matrices, determinants, orthogonality, eigenvalues and eigenvectors.

Prerequisite: Math 141.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Math 261 **Linear Algebra II**

Topics include the problem of similarity, Jordan canonical form, Euclidean and Hermitian spaces, orthogonality, normal operators, spectral theorem; and multilinear algebra, quadratic forms.

Prerequisite: Math 260.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Math 310 **Applied Ordinary Differential Equations**

Comprehensive study of ordinary differential equations. Series solutions to differential equations, Bessel functions, characteristic functions, Laplace transforms, and Fourier series.

Prerequisites: Math 240 and either Math 260 or Phys 114 (lab optional).

3 Lect Hrs, 3 Credits

Math 345 **Probability**

The mathematical study of the laws of random phenomena, including discrete and continuous random variables, expectation and variance, and common probability distributions such as the binomial, Poisson, and normal. Basic principles of combinatorics are introduced to solve problems in discrete probability spaces.

Prerequisite: Math 141 or permission of instructor.

3 Lect Hrs, 3 Credits

Math 346 **Mathematical Statistics with Applications**

This is a statistics course for students with a firm mastery of calculus, emphasizing the mathematical and conceptual bases of statistics, with a view to understanding the proper application of standard methods. The course includes thorough treatments of the Central Limit Theorem, the theory of estimation, hypothesis testing, and regression. (This course is normally offered once in two years.)

Prerequisites: Math 140, 141 and 345.

3 Lect Hrs, 3 Credits

Math 350 **Applied Partial Differential Equations**

Study of heat flow and other physical problems and the partial differential equation problems that arise from them, using the mathematical techniques of separation of variables, fundamental solutions, superposition, and characteristics. Use of Dirac delta function; asymptotics. Classification of partial differential equations. (This course is normally offered every third semester, in rotation with Math 354 and Math 358.)

Prerequisites: Math 240, Math 260, and Math 310.

Corequisite: Phys 113 (lab optional).

3 Lect Hrs, 3 Credits

Math 354 **Vector Calculus**

Differential and integral calculus of vector fields. Topics include line integrals, surface-area integrals, and smoothness; oriented curves and surfaces; circulation and flux of fields; Stokes' theorem; conservative, solenoidal fields; scalar, vector potentials; independence of path, surfaces, Maxwell's equations; and differential forms, exterior derivatives. (This course is normally offered every third semester, in rotation with Math 350 and Math 358.)

Prerequisite: Math 240.

Corequisite: Math 260.

3 Lect Hrs, 3 Credits

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Math 358

An Introduction to Complex Analysis

Complex numbers; complex functions; power series; trigonometric functions; Moebius transformations; differentiation and integration of analytic functions; Cauchy's theorem; residues; singularities; meromorphic functions. (This course is normally offered every third semester, in rotation with Math 350 and Math 354.)

Prerequisite: Math 310 or Math 354.

3 Lect Hrs, 3 Credits

Math 360

Abstract Algebra I

Review of set theory. Overview of algebraic structures. Elementary theory of groups, rings, and modules. (Course offered in the fall only.)

Prerequisite: Math 260.

3 Lect Hrs, 3 Credits

Math 370

History of Mathematics

This course traces the development of mathematics from ancient times up to and including the 17th century developments in the calculus. Emphasis is on the development of mathematical ideas and methods of problem solving. (This course is normally offered once every two years.)

Prerequisite: At least junior standing in mathematics.

3 Lect Hrs, 3 Credits

Math 425

Numerical Analysis

Approximations of roots. Finite differences. Interpolation. Numerical solutions of differential and algebraic equations.

Prerequisites: CS 260, and either Math 310 or 354, or permission of the instructor.

3 Lect Hrs, 3 Credits

Math 450

An Introduction to Real Analysis

A rigorous treatment of the calculus of functions of one real variable. Emphasis is on proofs. Includes discussion of topology of real line, limits, continuity, differentiation, integration and series.

Prerequisite: Math 310 or Math 354.

3 Lect Hrs, 3 Credits

Math 458

Theory of Numbers

Prime numbers; congruences and residues; approximation of real numbers by rationals; diophantine equations. (Course offered in the spring only.)

Prerequisite: Math 260 or CS 320 or equivalent

3 Lect Hrs, 3 Credits

Math 460

Survey of Geometry

Topics taken from classical Euclidean geometry and the non Euclidean geometries; projective geometry; lattices; finite geometries. (This course is normally offered at least once every two years.)

Prerequisite: Math 260.

3 Lect Hrs, 3 Credits

Math 470

Mathematical Logic

Syntax and semantics of propositional and first order predicate logic. Axiomatic theories and completeness. Brief discussion of incompleteness results.

Prerequisite: Math 260 or CS 320. or equivalent.

3 Lect Hrs, 3 Credits

Math 478

Independent Study

Work done by a student or group of students under faculty supervision on material not currently offered in a regularly scheduled course. Students wishing to undertake such work must first find a faculty member willing to supervise it; the work to be completed must be approved by the department chair.

Prerequisite: Permission of instructor.

3 Lect Hrs, 3 Credits

Math 479

Independent Study

See Math 478.

Math 480

Special Topics

An advanced course offering intensive study of selected topics in mathematics. A course offered as Math 480 is an advanced undergraduate mathematics course being given for the first time and covering topics not available in current courses. Such a course is offered either to fulfill a one-time need or to try out material with the intention of developing a new course. Course content varies each semester and will be announced prior to registration.

Prerequisite: Permission of department.

3 Lect Hrs, 3 Credits

Math 697a

Special Topics in Mathematics

An advanced course offering intensive study of selected topics in mathematics. Course content will vary according to the topic and will be announced prior to registration.

3-6 Lect Hrs, 3-6 Credits

Computer Science Courses

CS 105

An Introduction to Computer Concepts

This course presents an overview of the role of computers in society—their application and misapplication, their capabilities and limitations. Applications may include artificial intelligence, medical, aerospace and business use of computers. Computer hardware and associated technologies will be discussed. Computer programming will be taught from a non-mathematical, problem-solving point of view; the course objective is to help students acquire an understanding of the programming process, rather than to develop complex or extended computer programs. This survey course is not part of the computer science major sequence. Students planning to major in computer science should start with CS 110.

Note: No student will receive graduation credits for CS 105 if it is taken after successful completion of CS 110 or a higher level computer course.

Prerequisite: A suitable score on the mathematics diagnostic test

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

CS 110

An Introduction to Computing

An introduction to computer programming—the concepts involved in use of a higher level language and the program development process. The goal of this course is proficiency in the design and implementation of programs of significant size and complexity. This course is quite demanding because of the length of the programming exercises assigned. This is the first course in the computer science sequence. CS 110 is taught using the programming language Pascal. *Note:* Credit toward a UMass Boston degree may be awarded for only one elementary programming course. No credit will be given for CS 110 to a student who has already completed (or is currently taking) a similar course. For instance, a student who has received the equivalent of CS 110 as transfer credit cannot take CS 110 for credit here. Students who are barred from receiving credit for CS 110, but who are not fully prepared for CS 210, should request permission to take CS 119 (below) as a means of remedying this deficiency.

Prerequisite: A suitable score on the mathematics diagnostic test. Students who have passed Math 140 need not take the placement exam.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 4 Credits

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CS 119

Computer Language Supplement

This course addresses the dilemma of students who studied the equivalent of CS 110 in a language other than Pascal, but now need knowledge of Pascal in order to take CS 210. Such students can, with the permission of the department, register for CS 119 for two credits. They then make arrangements to attend a section of CS 110. They are required to do all the work of regular CS 110 students. However, CS 119 meets no core curriculum requirement and does not count towards any computer science major requirement.

Prerequisite: Permission of the department.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 2 Credits

CS 210

Intermediate Computing with Data Structures

The design and implementation of computer programs in a higher level language, with emphasis on proper design principles, proper utilization of advanced programming concepts, advanced features of programming languages such as pointers, recursion and types of parameter passing. Efficient design, implementation and debugging techniques are stressed. The assignments are designed to introduce the student to a variety of topics in computing: text processing, sorting, compiling and translation techniques. The language of instruction is Pascal.

Prerequisite: Fluency in Pascal, established by the successful completion of CS 110 or permission of the instructor.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 4 Credits

CS 240

Programming in C and Assembly Language

C and assembly language programming for programmers already knowledgeable in some high-level language, e.g., having taken one year of Pascal; C as a general purpose language and as a machine-level language. Low-level programming topics such as number representation, masking, bitwise operations, and memory allocation methods are covered, as are assembly language fundamentals sufficient to write small routines (with parameters) callable from C.

Prerequisites: CS 210 or permission of instructor.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Mr Bolker, Mr O'Neil, Mr Wortman

CS 241

Computer Organization and Architecture

Computer hardware concepts and hardware-level programming for C programmers. Topics are digital logic circuits, computer organization of a microprocessor system (i.e., how CPU, memory, and i/o interface chips are interconnected to make a system), serial and parallel port interfacing, hardware programming in C/assembler, interrupt programming, device drivers. The course includes a hands-on lab meeting one hour per week.

Prerequisite: CS 240.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

Mr Bolker, Mr O'Neil, Mr Wortman

CS 260

Numerical Computing

An introduction to the classical techniques of numerical analysis: root finding, approximation, interpolation, integration and the solution of systems of equations. A thorough discussion of problems of error and of floating and fixed point computation. Both implementation and analysis of the algorithms used will be stressed. Students will be expected to solve a number of numerical problems using FORTRAN. (Primarily for applications of interest to students in applied math, engineering, physics, chemistry, biology, psychology, and economics.)

Prerequisites: CS 110, Math 141 and Math 260 or permission of instructor.

Distribution Area: Mathematics and Computer Languages.

3 Lect Hrs, 3 Credits

CS 310

Advanced Data Structures and Algorithms

A systematic study of the methods of structuring and manipulating data in computing. Abstract data types. The design and analysis of algorithms. Advanced techniques for program development and organization.

Prerequisites: CS 210 and Math 140. CS 240 is a prerequisite or corequisite, but students are strongly advised to take CS 240 before CS 310.

3 Lect Hrs, 3 Credits

CS 320

Applied Discrete Mathematics

An introduction to the mathematical structures and concepts used in computing: sets, mathematical induction, ordered sets, Boolean algebras, predicate calculus, trees, relations and lattice theory, formal theory of languages and automata theory. Formal and informal theories and corresponding mathematical proofs are taught.

Prerequisites: CS 210 and Math 260 or permission of instructor.

3 Lect Hrs, 3 Credits

CS 330

An Introduction to Database Management Systems

A study of the systematic organization of large volumes of data. The concepts of Data Model, Data Dictionary, and the three main organizational methods: Network (CODASYL), Hierarchical, and Relational. A survey of programming techniques used with database systems. (Course not offered 1994-95 or 1995-96.)

Prerequisites: CS 310 and CS 320.

3 Lect Hrs, 3 Credits

CS 344

Systems Programming

This course teaches the functionality provided by and the use of a mainframe operating system—generally UNIX, although a different operating system may sometimes be substituted. Topics range from user (system utility) level to system manager (system generation) level. (Course not offered 1994-95 or 1995-96.)

Prerequisites: CS 240 and CS 310.

3 Lect Hrs, 3 Credits

CS 350

The Structure of Higher Level Languages

The syntax and semantics of higher level languages are treated using formal specifications of syntax and models of semantics. Important issues include mechanisms for parameter passing, scoping, dynamic storage allocation, and systems interfacing. Both compiled and interpreted languages are used as examples.

Prerequisites: CS 240 and CS 310.

Corequisite: CS 320.

3 Lect Hrs, 3 Credits

CS 410

An Introduction to Software Engineering

This course covers all aspects of the software development process from initial specification to final validation of completed software design. Implementation methodologies are discussed in the context of a major team project, to be chosen according to student and instructor interest.

Prerequisites: CS 310 and CS 320 CS 350 is strongly recommended.

3 Lect Hrs, 3 Credits

CS 420

An Introduction to the Theory of Computation

This course introduces such theoretical aspects of computing as models of computation, inherent limits on computation, and feasible computation. Topics include definition of computable functions (recursive functions, functions computable by Turing machines, functions computable in a programming language), unsolvability of the halting problem and related problems, the classes P and NP, finite automata, and context-free grammars.

Prerequisite: CS 320.

3 Lect Hrs, 3 Credits

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CS 440**An Introduction to Operating Systems**

Description of current operating systems, with focus on one or two in particular. Topics include defining the operating system as distinct from the hardware on one side and software systems on the other; process concepts; memory management; CPU scheduling; device management; file systems; network support.

Prerequisites: CS 241 and CS 310.

3 Lect Hrs, 3 Credits

CS 460**Graphics**

Topics include segmentation, windows and viewports, clipping, hidden lines, geometric transforms and data structures for memory management and device independent graphics specifications. The course also considers Raster graphics and such standards as the GKS and ACM Core. It covers both the practice of, and the underlying mathematical foundation for, interactive graphics programming. Students need good programming skills and a mastery of linear algebra at the level required for numerical computing.

Prerequisites: CS 260, Math 260, and CS 310, or permission of instructor.

3 Lect Hrs, 3 Credits

CS 470**An Introduction to Artificial Intelligence**

An introduction to the main techniques of Artificial Intelligence: state-space search methods, semantic networks, theorem-proving and production rule systems. Important applications of these techniques are presented. Students are expected to write programs exemplifying some of techniques taught, using the LISP language.

Prerequisites: CS 320 and CS 350/ Math 342, or permission of instructor.

3 Lect Hrs, 3 Credits

CS 478**Independent Study**

Work done by a student or group of students under faculty supervision on material not currently offered in a regularly scheduled course. Students wishing to undertake such work must first find a faculty member willing to supervise it; the work to be completed must be approved by the department chairperson.

Prerequisite: Permission of instructor.

3 Lect Hrs, 3 Credits

CS 480**Special Topics**

An advanced course offering intensive study of selected topics in computer science. Course content varies and will be announced prior to registration.

Prerequisites: Permission of the department.

3 Lect Hrs, 3 Credits

Graduate Courses**CS 610****Advanced Software Engineering I**

Introduction to modern program development techniques. Students are exposed to current advanced design and implementation techniques, such as object-oriented programming; they develop programs in these styles. Programming projects for the course include design and test plan documentation as well as implementation in modern programming languages such as C++ or the Common Lisp Object System.

Completion of this course with a grade of B or better is required for admission to the remainder of the advanced software engineering sequence (CS 611, CS 612 and CS 613).

Prerequisites: CS 310, CS 320, and proficiency in C programming.

3 Lect Hrs, 3 Credits

CS 611**Laboratory in Software Engineering I**

First half of a two-semester laboratory course in which students, working in small groups, specify, design, implement, and document a large software project. (Course offered in the fall only.)

Prerequisites: B or better in CS 610.

Corequisite: CS 612 is a .

3 Lect Hrs, 3 Credits

CS 612**Advanced Software Engineering II**

This course is concerned with long-term, large-scale programming projects. Topics include software engineering management, problem analysis, problem specification, system design, system documentation, testing, performance evaluation, system maintenance, current and future software environments. Modern design and such implementation methodologies as object-oriented programming, rapid prototyping are discussed. (Course offered in the fall only.)

Prerequisite: A grade of B or better in CS 610.

Corequisite: CS 611

3 Lect Hrs, 3 Credits

CS 613**Laboratory in Software Engineering II**

A Continuation of CS 611. (Course offered in the spring only.)

Prerequisites: CS 611, CS 612.

3 Lect Hrs, 3 Credits

CS 615**User Interface Design**

An introduction to user interface design, which encompasses design of the user interface and the functional design of the whole system. Students read and critique papers and articles, evaluate and critique existing user interfaces and design interfaces of their own. Working in small groups, they use either interface prototyping tools or conventional rapid prototyping systems to construct an experimental interface.

Prerequisites: CS 310, CS 320.

3 Lect Hrs, 3 Credits

CS 620**The Theory of Computation**

Functions computable by programs. Recursive functions and Turing machines; simulation and diagonalization. Universality and unsolvable problems. Kleene's hierarchy and the recursion theorem. Gregorczyk's hierarchy and Ackermann's function. Abstract complexity and the speed-up theorem. Formal languages and classes of automata. Inherently difficult combinatorial problems.

Prerequisites: CS 310 and CS 320.

3 Lect Hrs, 3 Credits

CS 622**The Theory of Formal Languages**

This course treats languages from an abstract point of view as defined by formal grammars and by families of abstract machines. It covers the Chomsky/hierarchy and associated automata; and emphasizes context-free languages. Careful mathematical definition and proof is stressed throughout. This course does not involve programming. It is of special interest to students interested in linguistics and in the theory of programming language compilers.

Prerequisites: CS 320 and CS 350, or permission of instructor.

3 Lect Hrs, 3 Credits

CS 624**Analysis of Algorithms**

Basic techniques for designing algorithms: divide and conquer, the greedy method, dynamic programming, etc. Applications to searching and sorting algorithms. Complexity of parsing. The fast Fourier transform and its applications (evaluation of polynomials and arithmetical problems). Lower bound theory. NP-hard and NP-complete problems. Probabilistic estimates of algorithms. Recurrence relations and other techniques for the analysis of recursive algorithms.

Prerequisites: CS 310 and CS 320.

Math 330.

3 Lect Hrs, 3 Credits

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CS 630**Database Management Systems**

The value of a database management system (DBMS). The relational model. Using relational algebra to form queries. The computer query language SQL, with lab work on the INGRES DBMS product; additional exposure to concepts in the ORACLE and DB2 products. Embedded SQL in programs and dynamic SQL. Database administration: creating views and integrity constraints, handling data security, and creating table indexes. Database design (normalization). Query optimization. The Set Query benchmark and considerations of cost-performance.

Prerequisites: CS 240 or equivalent, and CS 320.

3 Lect Hrs, 3 Credits

CS 632**Relational Databases**

Material required for the understanding, design and implementation of current state-of-the-art relational databases. Functional and multivalued dependencies, normal forms, tableaux, query systems. A comparative study of several relational query languages.

Prerequisite: CS 630.

3 Lect Hrs, 3 Credits

CS 634**Architecture of Database Systems**

A study of the architecture and performance of centralized and distributed database management systems. The study will cover the following topics in depth: atomic actions; the transaction and its implementation as an atomic action; serial and concurrent execution of transactions; concurrency control mechanisms for centralized and distributed database systems; concurrency control problems such as deadlock, transaction roll-back, and transaction blocking; serialization and database recovery.

3 Lect Hrs, 3 Credits

CS 640**Operating Systems**

Structure and dynamics of operating system software. Operating systems as event-driven software: interrupt processing and asynchronous operation. Memory management, scheduling, concurrency, consideration, device drivers. Examples taken from such systems as UNIX.

Prerequisites: CS 310 and two graduate Computer Science courses or CS 440.

3 Lect Hrs, 3 Credits

CS 642**Performance Modeling**

A survey of the techniques for the mathematical modeling of complex systems and the analysis of models using both analytic techniques and simulation. Particular attention will be paid to the construction of queuing theory models of computer operating systems, and the use of these models for understanding and predicting system performance. (Course not offered 1994-95 or 1995-96.)

Prerequisites: Math 345 and CS 440.

3 Lect Hrs, 3 Credits

CS 644**Computer Architecture**

An examination of the designs for hierarchical memory systems including caches and virtual memory systems, pipeline design techniques, characteristics of RISC/CISC machines, multi-processor systems including multiprocessors and loosely-coupled computer systems, the micro engine and microprogrammed machines, vector and array processors, and the cost/performance trade-offs in the all of the above designs.

Prerequisites: CS 241 and CS 310. CS 440 is recommended.

3 Lect Hrs, 3 Credits

CS 646**Computer Communications Networks**

Need for computer networks. Architectures of networks. Architectures of systems. ISO reference model. Standardization efforts. Specification of protocols. Example protocols and networks.

Prerequisite: CS 440.

3 Lect Hrs, 3 Credits

CS 650**Compilers I**

Introduction to compiler organization and construction techniques. Lexical analysis, parsing, symbol tables and attributed syntax trees. Internal forms of the source program. Storage allocation, error recovery. Translation systems. Programming practice writing a compiler for a reasonably large subset of ALGOL, Pascal or similar algebraic language.

Prerequisites: CS 240, CS 320, and CS 350.

3 Lect Hrs, 3 Credits

CS 652**Compilers II**

Extension of topics in CS 650 with emphasis on code generation and optimization. Case studies of existing implementations.

Prerequisite: CS 650.

3 Lect Hrs, 3 Credits

CS 654**The Semantics of Programming Languages**

This course presents some of the theoretical foundations of software engineering. Its main objectives are to enable programmers to formulate rigorous statements about the behavior of programs and to define precisely the meaning of different constructs occurring in programming languages.

Prerequisites: CS 320, CS 350, CS 622, and Math 470 or the equivalent.

3 Lect Hrs, 3 Credits

CS 656**Logic Programming**

This is a course in the theoretical and practical aspects of logic programming. Topics include semantics of logic programming, negation in logic programming, metalevel reasoning, concurrency, databases, expert systems.

Prerequisites: CS 320 and Math 470.

3 Lect Hrs, 3 Credits

CS 662**Document Preparation and Text Processing Systems**

An applied course in contemporary document preparation systems.

Prerequisite: CS 320.

Corequisite: CS 610 and permission of the instructor.

3 Lect Hrs, 3 Credits

CS 664**Image Processing**

Techniques of digital image processing. Topics include processing in the image and spatial frequency domains; Fourier and other transforms, continuous and discrete convolution and filtering; Grey-level transforms, feature identification, image encoding, image enhancement; applications to models of human and machine vision.

Prerequisites: Math 240 and 260, or permission of the instructor.

Department of Modern Languages

Department of Mathematics and Computer Science

CS 670

Artificial Intelligence

The application of the methods of artificial intelligence programming to state-of-the-art expert systems, advice-taking systems and natural language understanding software. The course is project oriented. Students work in teams developing a large system, and become familiar with major research journals.

Prerequisites: CS 350, CS 470, Math 470 or equivalent background in logic and LISP, and permission of the instructor.

3 Lect Hrs, 3 Credits

CS 696

Independent Study

This independent study course covers material not available in normal departmental offerings.

3 Lect Hrs, 3 Credits

CS 697

Special Topics

Topics of current interest in the field, according to student and faculty areas of specialization.

3 Lect Hrs, 3 Credits

Faculty

Diana L Burgin, Professor and Chair; Professors Alfred Hoelzel, F Peter Ott, Brian Thompson; Associate Professors, Fiora Bassanese, Antonio Carrara, Carl Cedargren, Lynn Dhority, Edythe Haber, Ritta Jo Horsley, Monique Stern, Gerald C Volpe; Assistant Professors Rose Abendstern, Andrew Boelcskev

The Department*

The Department of Modern Languages offers strong and varied programs in French, German, Italian, and Russian language, culture, and literature, taught by a faculty with considerable international experience. Course offerings are designed to serve the educational needs of students who want to acquire a knowledge of foreign languages from the elementary to the advanced level, and who wish to explore the richness of European literary and cultural traditions.

The main objective of the department's academic programs is to provide students with practical and intellectually challenging undergraduate study that will enable them to make effective use of a foreign language in pursuit of their professional and personal goals. Students can major or minor in any of the department's four languages. Both major and minor programs give students considerable flexibility in selecting from among required courses; independent study and graduation with honors are available for majors in any of the department's languages.

Our course offerings also enable students majoring in other disciplines to develop knowledge of a second language and an awareness of cultural diversity. Many offerings are interdisciplinary, and several are given in English; these include an extensive selection of core courses in several distribution areas.

*The Department of Modern Languages incorporates the programs previously housed in the Departments of French, German and Russian, and Italian.

French

Requirements and Recommendations

The Major

Majors are required to take a minimum of ten departmental courses at the 300 or 400 level. At least five of these must be taken at UMass/Boston. Students choosing to major in French may to a large extent design a program which reflects their own interests and objectives. Only three specific courses (or their equivalents) are required of all students: French 301, 302, and 303.

Beyond these three courses, majors may group the remaining seven required courses on one of two tracks. The track in French literature requires at least five upper-level literature courses, representing at least three different centuries; plus at least two upper-level courses in language or culture. The track in French language and culture requires at least five upper-level courses in language or culture; plus at least two upper-level courses in literature.

Specific information about matching particular courses to either of the two tracks is available from the departmental advisor to majors, or from the chairperson.

Other requirements for majors:

1. Students must attain a 2.0 GPA in the major by the time they graduate.
2. No upper level course may be taken for major credit on a pass/fail basis.

The Minor

Students majoring in another discipline may minor in French. They should discuss their program with the departmental chairperson. Minimal requirements include:

1. Intermediate competence (French 201-202 or equivalent)
2. French 301 Composition et stylistique (or equivalent)
3. Three additional courses at the 300 or 400 level, in French language, literature or civilization.

Honors

To graduate with departmental honors, the French major must work on an honors thesis written in French under the direction of an advisor from the French faculty, and make an oral defense of this thesis in which the candidate is asked questions in the general area of his or her written work. The honors thesis and the oral defense are evaluated by a departmental Honors Committee.

The candidate must also attain at least a 3.5 GPA in major courses and a 3.0 GPA overall. Further information about departmental honors is available from the department chairperson.