

- **MATHEMATICS**
- **COMPUTER SCIENCE**
- **APPLIED MATHEMATICS**
- **STATISTICS**

AT Kent State University

**DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE
UNDERGRADUATE PROGRAMS
1995-96**

At Kent State University the primary concern is the student. The Department of Mathematics and Computer Science reflects this concern through its efforts to provide the academic atmosphere and close student-faculty associations which encourage intellectual growth and development. Programs are designed to broaden students' perspectives and to help them realize their potential. Course offerings include mathematics (pure and applied), computer science, statistics, and mathematics for teachers. A student may concentrate in one area or combine coursework from several areas. Programs allow a student to prepare for graduate study, for high school teaching, or for employment in industry.

An undergraduate specializing in Mathematics and Computer Science will begin with calculus and introduction to computing, although some students will require college algebra and trigonometry. Well-prepared students are encouraged to establish credit in elementary courses by passing advanced standing examinations. All majors take courses in calculus, computer science, and linear algebra.

PREPARATION FOR A MATHEMATICS CAREER

Students interested in careers as mathematicians should pursue either the Mathematics Program or the Applied Mathematics Program. The Mathematics Program is strongly recommended for students considering graduate study in mathematics. The Applied Mathematics Program is flexible and designed to suit the needs of students interested in a career in industry and government or in postgraduate study in applied mathematics or other scientific areas. It is strongly recommended that all majors plan to take the Graduate Record Examination (GRE) early in their senior year.

PREPARATION FOR A COMPUTER SCIENCE CAREER

Computer scientists are in great demand in teaching, government, and industry. Students interested in a computer science career should pursue the Computer Science Program. The Computer Science Program is strongly recommended for students considering graduate study in computer science. To increase one's chances at some of the most competitive graduate programs, an individual project course or honor's thesis is recommended.

PREPARATION FOR A TEACHING CAREER

Students interested in high school teaching may pursue either the Bachelor of Science or Arts in the College of Arts and Sciences, majoring in one of the mathematical sciences with a minor in secondary education or the Bachelor of Science in Education, with a major or minor in mathematics. Either of these programs leads to teacher certification in the State of Ohio.

JOB OPPORTUNITIES

A degree in the mathematical sciences can lead to various careers in education, industry, and government. Because of the skill in reasoning developed by mathematical training, a degree in mathematics is a positive asset when applying for any position. The pamphlet, PROFESSIONAL OPPORTUNITIES IN MATHEMATICS, provides an excellent summary of different types of jobs which use mathematics, approximate salaries, and educational requirements.

This pamphlet is available by sending 50 cents to:

The Mathematical Association of America
1529 Eighteenth Street, N.W.
Washington, D.C. 20036

For job opportunities in Computer Science, the booklet, THE NO NONSENSE GUIDE TO COMPUTING CAREERS, is available directly from the Association of Computing Machinery at the following address:

Association for Computing Machinery
1515 Broadway New York, NY 10036
(phone: 216-869 7440)

A discount is available for student members of the national ACM organization.

The Kent State University Career Planning and Placement Center in the Michael Schwartz Center has an excellent resource library on careers in mathematics and computer science.

DEPARTMENTAL HARDWARE

In August 1992, the Department of Mathematics and Computer Science moved into the new 7.5 million-dollar Mathematics and Computer Science Building. This modern facility includes three large computer laboratories (two X-terminal and workstation labs and one PC lab) for use by undergraduate and graduate students. In addition, there are special purpose laboratories devoted to parallel processing, symbolic and numerical computation, operating systems and networking, and graphics.

The departmental educational computing facilities currently include a four processor Sun 4/670, HP/Apollo 700 series workstations, a Wavetracer DTC SIMD machine which is accessible from the graduate and undergraduate X-terminal and workstation labs and from the PC lab.

All departmental machines are also connected to OARNET (Ohio Academic Research Network) and the Internet. Interactive access to a Cray YMP/8 and a Cray T3D at the Ohio Supercomputing

Center in Columbus is also available for advanced students. The departmental local area network (LAN) is connected by fiber optic cable to the central university computing facility, and by T-1 link to the OARNET, NSFnet and Internet. The backbone of the network is an Artel Galactica intelligent bridging hub. This has a one Gigabyte/sec backplane and supports simultaneous transfers at a 10 Mbyte/sec data transfer rate between any two bridging segments, and between multiple Ethernet segments.

ADVISING

Students interested in majoring in mathematics, applied mathematics or computer science should visit the Mathematics and Computer Science Department Office for assignment of a faculty advisor. Students may request a particular faculty member for an advisor. The advisors help the students choose the appropriate program according to their goals, needs, and interests; help plan short-range and long-range schedules for coursework; provide information about the material covered in specific courses; give advance information on the scheduling of courses; provide information on careers; keep a record of each student's progress in completing a particular program; and make referrals to other campus offices for help in cases of need.

The Department of Mathematics and Computer Science feels strongly that the departmental advising system plays an invaluable role in planning the student's course study and contributes greatly to the student's educational experience. Each mathematics or computer science major is expected to visit his/her advisor each semester. The advisor can be changed upon request by the student. Departmental information such as advance schedules for courses, rotation of course information, announcements, documents, employment information, and general information is available electronically at the WWW site "<http://www.kent.edu.home.html>." Local users can use lynx or Xmosaic to access this site.

GRADUATE SCHOOL

Students planning to take graduate courses in mathematics at some time in the future should take MATH 42001-2 (Analysis I & II) and Math 41001-2 (Modern Algebra I & II) before graduating.

Each year the Department of Mathematics and Computer Science has a meeting for students interested in graduate work and information is distributed at this meeting on graduate schools, financial support, and career opportunities. Each mathematics or computer science major interested in graduate work should notify the Coordinator of Undergraduate Studies.

Kent State University offers the following graduate degrees in Mathematics and Computer Science (M.A., M.S. and Ph.D.):

- Master of Arts
- Master of Arts in Teaching (Mathematics)
- Master of Science
- Doctor of Philosophy

Detailed information on the specific requirements for these degrees and on financial support can be obtained from the Coordinator of Graduate Studies. The Kent State University deadline for completed applications is March 1 for admission with financial support and July 7 for admission only.

GENERAL MATHEMATICS - COMPUTER SCIENCE REQUIREMENT

The general requirement is a block of courses required for all degree programs. These courses should be taken during the first two years of coursework with the calculus sequence being started as soon as possible. The Algebra and Trigonometry course (MATH 12001) is a prerequisite for calculus which the student with sufficient background should bypass. This course may be waived by obtaining permission from the Department of Mathematics and Computer Science or by passing the placement exam given by the Examination Aids Center.

The required courses are:

	12002	Analytic Geometry & Calculus I	5
	12003	Analytic Geometry & Calculus II	5
	21001	Linear Algebra with Applications	3
CS	10061	Introduction to Computing	3

APPROVED MATHEMATICS, COMPUTER SCIENCE, AND ALLIED COURSES

To allow the student leeway for designing a cohesive program for his/her particular interests, each of the Mathematics and Computer Science degree programs allows a selection of courses from mathematics, computer science, and allied areas. Because of the many departmental course offerings and the unfamiliarity of most students with scope of and relations between various courses, it is required that the courses which require approval be approved by the student's departmental advisor at the Kent Campus of Kent State University *prior to enrollment*. Any student not obtaining prior advisor's approval for 40000-level courses may be required to petition the Undergraduate Studies Committee for approval.

COLLEGE OF ARTS AND SCIENCES PROGRAM

The College of Arts and Sciences offers a Bachelor of Science degree (B.S.), with Mathematics, Applied Mathematics or Computer Science as majors and the Bachelor of Arts degree (B.A.) with Mathematics as a major. To obtain any of these degrees, the general requirements of the college must be satisfied along with the departmental requirements listed below.

BACHELOR OF ARTS

General Mathematics - Computer Science Requirement	16
22005 Analytic Geometry & Calculus III	3
<i>One of the following sequences:</i>	6
(1) 41001 Introduction to Modern Algebra I	
41002 Introduction to Modern Algebra II	
(2) 42001 Introduction to Analysis I	
42002 Introduction to Analysis II	
Approved 40000-level MATH or Computer Science courses	9
	<hr/>
	34

BACHELOR OF SCIENCE

There are three degrees awarded in Mathematics and Computer Science: the Bachelor of Science in Mathematics, the Bachelor of Science in Applied Mathematics, and the Bachelor of Science in Computer Science.

BACHELOR OF SCIENCE IN MATHEMATICS

General Mathematics - Computer Science Requirement	16
MATH 22005 Analytic Geometry & Calculus III	3
41001, 41002 Introduction to Modern Algebra I, II	6
41021 Theory of Matrices	3
42001, 42002 Introduction to Analysis I, II	6
PHY 23101 General University Physics I	5
Approved 40000-level MATH or CS courses	9
Approved coursework from upper-division MATH courses or CS courses or from majors courses in ADMS, BSCI, CHEM, CS, ECON, GEOL or PHY or from PHIL 31045, 41035 or 41045.	19
	<hr/>
	67

BACHELOR OF SCIENCE IN APPLIED MATHEMATICS

	General Mathematics - Computer Science Requirement		16
MATH	22005	Analytic Geometry & Calculus III	3
	31011	Discrete Mathematics I	3
	40011	Introduction to Probability Theory & Applications	3
MATH	40012	Introduction to Statistical Concepts	3
	41021	Theory of Matrices	3
	42031	Mathematical Models	3
	42044	Applied Analysis I	4
	42045	Applied Analysis II	4
	42201	Introduction to Numerical Computing I	3
	42202	Introduction to Numerical Computing II	3
CS	23021	Intermediate Programming & Applications	3
	33001	Data Structures	3
PHY	23101, 23102	General University Physics I,II	10
	Approved upper division courses for majors in ONE of CS, MATH, PHY or CHEM		6
			<hr/> 70

BACHELOR OF SCIENCE IN COMPUTER SCIENCE

MATH*	12002-3	Analytic Geometry and Calculus I, II	10
MATH	21001	Linear Algebra With Applications	3
CS	10061	Intro. to Computer Science	3
	23021	Intermediate Programming and Applications	3
	31011	Discrete Mathematics I	3
	33001	Data Structures	3
	33003	Assembly Language Programming	3
	33005	Symbolic Programming Languages	3
	33006	Social and Ethical Issues in Computing	3
	43101	Structure of Programming Languages	3
	43111	Structure of Compilers	3
	43201	Operating Systems	3
	45101	Computer Organization and Architecture	3
	46101	Design and Analysis of Algorithms	3
plus	one of	the following	3
MATH	22005	Analytic Geometry and Calculus III	3
		<i>or</i>	
CS	31012	Discrete Mathematics II	3
PHY	12411	Introduction to Computer Hardware	3
plus	one of	the following	3
CS	42201	Numerical Computing I	3
	46201	Automata, Formal Languages and Theory of Computability	3
plus	approved	40000-level CS courses	6
**plus	approved	upper-division CS courses	<u>6</u>
			70

*MATH 12001 is a prerequisite for calculus which the student with sufficient background should bypass.

**With the advisor's permission computer related upper-division courses, normally from MATH, PHY or ADMS may replace some of these hours.

A MINOR IN MATHEMATICS OR COMPUTER SCIENCE

It is possible for a student to major in Computer Science and minor in Mathematics or the other way around. Computer Science majors wishing to apply for admission and financial support to some of the highly competitive graduate programs in computer science are strongly encouraged to obtain at least a minor, and preferably a major, in Mathematics (pure or applied). The requirements for the minor are listed below. For students interested in Secondary Education, see below for the requirements for a major or minor in Mathematics.

Minor in Mathematics

General Mathematics Requirement		16
MATH 22005 Analytic Geometry & Calculus III		3
One of the following:		3-4
MATH 41001 Introduction to Modern Algebra I	3	
MATH 42001 Introduction to Analysis I	3	
MATH 42044 Applied Analysis I	4	
Elective courses:		9
9 hours selected from 40000-level mathematics courses in consultation with the student's minor advisor.		

Minor in Computer Science

Basic courses		13-17
CS 10061 Introduction to Computer Science	3	
*MATH 12001 Algebra & Trigonometry (may be bypassed with permission)	4	
MATH 12002 Analytic Geometry & Calculus I	5	
MATH 12003 Analytic Geometry & Calculus II	5	
Core courses:		6
CS 23021 Intermediate Programming & Applications	3	
CS 33001 Data Structures	3	
Elective courses:		12
12 hours selected from upper division computer science courses in consultation with the student's minor advisor		

*MATH 12001 is a prerequisite for calculus which the student with sufficient background should bypass.

MINOR IN SECONDARY EDUCATION

Candidates for either the B.A. or B.S. degree in the College of Arts and Sciences may complete requirements for a minor in secondary education leading to teacher certification in the State of Ohio. Application should be made in the Office of the Assistant Dean for Student Personnel, 306 White Hall. All mathematics requirements for the B.A. or B.S., and the Secondary Education Mathematics Requirements listed under the Bachelor of Science in Education degree must be satisfied. A course may be used to satisfy a requirement in both programs.

SECONDARY EDUCATION MATHEMATICS REQUIREMENT

General Mathematics - Computer Science Requirement		16
MATH 22005 Analytic Geometry & Calculus III		3
31011 Discrete Mathematical Structures		3
34002 Fundamental Concepts of Geometry		3
One of the following		3
34001 Fundamental Concepts of Algebra		3
*41001 Introduction to Modern Algebra I		3

One of the following	3
MATH *41001 Introduction to Modern Algebra I	3
42001 Introduction to Analysis I	3
46001 Elementary Topology	3
47011 Theory of Numbers	3
One of the following	3
MATH 45011 Differential Geometry	3
45021 Euclidean Geometry	3
45022 Linear Geometry	3
One of the following	3-4
MATH 40011 Introduction to Probability Theory & Applications	3
42011 Mathematical Optimization	3
42021 Graph Theory and Combinatorics	3
42031 Mathematical Models	3
42044 Applied Analysis I	4
42048 Introduction to Complex Variables	3
42201 Introduction to Numerical Computing I	3
Approved 40000-level MATH courses (*) (**)	3

* Note that MATH 41001 can be used to satisfy both requirements but then 6 hours of approved MATH 40000 level courses are required.

** These courses must be approved by the advisor before enrolling in them. The following courses will not apply toward approved 40000-level MATH electives: MATH 44001-44014, 44020, 47091, 47096.

The Bachelor of Science in Education degree (B.S. in Ed.) is granted by the College of Education. The student devotes approximately one-fifth of his/her time to professional preparation. To obtain this degree with either a major or minor in mathematics the general requirements of the College of Education must be satisfied along with the mathematics requirements listed below.

Minor in Mathematics

General Mathematics - Computer Science Requirements	16
MATH 31011 Discrete Mathematical Structures	3
Group A	6
NOTE: At least one 40000-level course must be taken	
One of the following	
MATH 34001 Fundamental Concepts of Algebra	3
41001 Introduction to Modern Algebra I	3
One of the following	
MATH 34002 Fundamental Concepts of Geometry	3
45021 Euclidean Geometry	3
45022 Linear Geometry	3
Group B Two of the following	6-7
MATH 22005 Analytic Geometry & Calculus III	3
30011 Basic Probability & Statistics	3
40011 Introduction to Probability Theory & Applications	3
42001 Introduction to Analysis	3
42044 Applied Analysis I	4
42048 Introduction to Complex Variables	3
42201 Introduction to Numerical Computing I	3
47011 Theory of Numbers	3

AWARDS AND SCHOLARSHIPS

1. Pi Mu Epsilon Award (\$100.00 and a book)
Awarded to an outstanding upper-class student in Mathematics.
2. Kenneth B. Cummins Mathematics Scholarship (amount of award varies).
Awarded to the most promising junior major in pure mathematics. Application forms available from the departmental office.
3. Kenneth B. Cummins Mathematics Award (amount of award varies)
Awarded to the most promising junior mathematics major preparing to teach mathematics in the secondary schools. Application forms available from the departmental office.
4. Harshbarger Scholarship (amount of award varies).
Available to any major who has completed the general Mathematics-Computer Science requirement (see page 2) and either MATH 22005 (third semester calculus) or an upper-division mathematics or computer science course. Application forms available from the departmental office.
5. Honorary Mathematics-Computer Science Scholarship (\$1500).
This scholarship is offered jointly with the Honors College and is awarded to a talented freshman who has demonstrated truly unusual or exceptional proficiency in mathematical skills (for example: achieving a high ranking on the AHSME).

Other scholarships not directly awarded by the Department may be available. For example, for the past several years, awards running as high as \$750 have been made to majors through a Lubrizol Scholarship furnished by the Lubrizol Corporation. This is awarded to majors based on scholastic ability. The recipient must attend the University during the entire academic year for which the award applies. During alternate years, the Akron Council of Engineering and Scientific Societies (ACCESS) awards a \$1000 scholarship to a deserving science/engineering undergraduate. (Computer Science majors fall in this category). Next ACCESS available: 1996-97, (nominations sought in January 1996).

COMPUTER SCIENCE

- 10001 **COMPUTER LITERACY (3)**
Introduction to history, language, procedures, applications, abuses, and impact of computers. Hands-on experience with micro-computers. Not open to students with previous experience.
- 10051 **AN INTRODUCTION TO COMPUTERS & COMPUTER PROGRAMMING (3)**
An overview of computer hardware, software, uses, limitations, and to modern trends in computing. An introduction to computer programming and to solving problems with a computer. Prerequisite: Three years of high school math. No credit for CS 10061, 10060.
- 10060 **ELEMENTARY FORTRAN COMPUTING (3)**
Introduction to computing. Fortran is applied to problems of interest in technical and non-technical areas. Not counted toward majors in Department of Mathematics and Computer Science. Prerequisites: MATH 11011, 12001 or placement and no credit for 10061, 10051.
- 10061 **INTRODUCTION TO COMPUTER SCIENCE (3)**
Emphasizes programming in a high level language, includes structured programming, program design, expressions, data control, arrays, records, strings, and functions. Prerequisites: CS 10051 or placement test.
- 23021 **INTERMEDIATE PROGRAMMING AND APPLICATIONS (3)**
Techniques for solving computational models in various disciplines; includes programming style, linked lists, recursion, basic data structures, searching and sorting techniques. Prerequisite: CS 10061
- 23031 **COMPUTERS IN ARCHITECTURE (3)**
Use of computers by architects in problems of design, information retrieval, simulation, management, and technical applications. Prerequisite: Sophomore architecture major.
- 31011 **DISCRETE MATHEMATICS I (3)**
(cross-listed with MATH 31011)
Discrete mathematical techniques and structures including finite set theory, graph theory, propositional calculus, combinatorics, and discrete probability. Formal methodology and proof techniques. Prerequisites: MATH 12002 and MATH 21001 (concurrent registration in MATH 21001 allowed).
- 31012 **DISCRETE MATHEMATICS II (3)**
(Cross listed with MATH 31012)
A continuation of Discrete Math I: emphasizing advanced combinatorial techniques such as partitions, graph applications in algorithms, and finite algebraic structures. Prerequisite: CS 31011 or MATH 31011 and MATH 21001 (concurrent registration in MATH 21001 allowed).
- 33001 **DATA STRUCTURES (3)**
Introduction to computer data representation: stacks, queues, dequeues, sequential and linked allocation, trees, graphs. Efficient algorithms for manipulation of data structures. Prerequisites: CS 23021, MATH 12003, or permission.
- 33003 **COMPUTER ORGANIZATION & ASSEMBLY LANGUAGE (3)**
Introduction to structure and organization of digital computers; representation, manipulation, and flow of information in binary form, and introduction to the CPU and assembly language. Prerequisite: CS 23021 or ADMS 24002.
- 33004 **C PROGRAMMING (3)**
Structured programming concepts in C including lexical elements, data types, control structures, expressions, arrays, pointers, records, functions, advanced data structures, and standard library functions (no credit for CS majors). Prerequisite: Knowledge of a high level programming language.

- 33005 **SYMBOLIC PROGRAMMING LANGUAGES (3)**
An introduction to programming languages, such as Lisp and Prolog, which are used in symbolic programming in such areas as artificial intelligence and computer algebra. Prerequisite: CS 23021
- 33006 **SOCIAL AND ETHICAL ISSUES IN COMPUTING (3)**
Social issues, including historical and social context, professional responsibilities, risks and liabilities, and intellectual property. Prerequisite: CS 33001 (concurrent registration is allowed).
- 33095 **SELECTED COMPUTER LANGUAGES (2)**
A language like PL/1, ALGOL, ADA, or an assembly language is selected and listed in the *Schedule of Classes*. Repeated registration permitted for different languages. Prerequisites: CS 23021 or ADMS 24002 and permission.
- 33201 **MICROCOMPUTER SYSTEMS & LOCAL NETWORKS (3)**
Considers architecture, organization, and uses of microcomputers. Typical microprocessors and microcomputer hardware and software are discussed. Students will gain hands-on experience with a microcomputer. Prerequisite: CS 33003; PHY 12411 (recommended).
- 42201 **NUMERICAL COMPUTING I (3)**
(cross-listed with MATH 42201)
Numerical algorithms, recursion formulas, error analysis, interpolation, least squares approximation, data reduction, numerical linear algebra, solution of nonlinear equations, methods implemented using algorithmic programming language. Prerequisites: CS 10061, MATH 12003, and MATH 21001.
- 42202 **INTRODUCTION TO NUMERICAL COMPUTING II (3)**
(cross-listed with MATH 42202)
Difference operators, difference equations, numerical integration and differentiation, extrapolation methods. Numerical solution of initial boundary, and eigenvalue problems for ordinary and partial differential equations. Prerequisites: MATH/CS 42201, and MATH 42044.
- 43006 **OBJECT-ORIENTED PROGRAMMING (3)**
Introduction to the concepts, techniques and languages related to Object-Oriented Programming (OOP), a software methodology addressing program flexibility, maintainability, modularity, and reusability. Prerequisite: CS 33001 or permission.
- 43007 **LOGIC PROGRAMMING (3)**
Predicate Calculus, SLD-resolution, Unification, AND-OR tree. Logical data structures, Recursion, Cuts, Negation, Difference-lists, dictionaries, Meta-interpreters, Parallelism, Applications in Compilers and AI. Prerequisites: CS 33001, 33005, or permission.
- 43101 **STRUCTURE OF PROGRAMMING LANGUAGES (3)**
A study of major concepts in modern programming languages, such as syntax,, semantics, data types, concurrency, various program paradigms, and design and implementation issues. Prerequisites: CS 33001 and CS 33005.
- 43111 **STRUCTURE OF COMPILERS (3)**
Techniques used to write and modify compilers including translation, forcing tables, loading, storage allocation, symbol tables, object code, optimization, error diagnostics, and overall design. Prerequisites: CS 33001, 43101, 45101.
- 43201 **OPERATING SYSTEMS (3)**
Introduction to operating systems, interrupt handling, process control, asynchronous concurrent processes, real and virtual memory management, I/O and file systems. Prerequisites: CS 33001 and CS 33003.

- 43203 **SYSTEMS PROGRAMMING (3)**
Implementation and maintenance of systems programs, system utilities, command interpreters, editors, file maintenance programs, text processors, interrupt handling, device drivers. Prerequisite: CS 43201.
- 43301 **PARALLEL PROGRAMMING (3)**
Programming concepts for SIMD (Single Instruction Multiple Data) and MIMD (Multiple Instruction Multiple Data) parallel computers. Prerequisites: CS 33001 & CS 45101.
- 43901 **SOFTWARE ENGINEERING PROJECTS (3)**
(repeated registration permitted with permission)
An introduction to software development techniques including experience in team programming on a large project. Prerequisite: CS 33001 or permission.
- 44201 **ARTIFICIAL INTELLIGENCE (3)**
Examines goals, problems, concepts and methods of artificial intelligence, the LISP programming language, heuristic versus algorithmic methods, natural language comprehension, theorem proving. Prerequisite: CS 33001 and CS 33005.
- 45101 **COMPUTER ORGANIZATION & ARCHITECTURE (3)**
Functional overview of computer systems and organization, interconnection of basic components, input-output control, memory systems, interrupts, virtual addressing, stack architecture, parallel and pipeline processing. Prerequisites: PHY 12411, and CS 23021, and CS 33003.
- 45111 **PRINCIPLES OF CUSTOMIZED VLSI DESIGN (3)**
Introduction to the design, implementation, and realization of VLSI systems. Requires designing parts of a custom designed chip using interactive tools. Prerequisite: CS 45101.
- 45201 **COMPUTER COMMUNICATIONS NETWORKS (3)**
Provides a comprehensive treatment of the analysis and design of computer networks; data communications techniques, network architecture, OSI models and protocols, LANs, routing techniques, and congestion control. Prerequisite: CS 45101.
- 46101 **DESIGN & ANALYSIS OF ALGORITHMS (3)**
Introduction to algorithmic concepts, practical techniques for the design and analysis of algorithms; searching, sorting, integer and floating point arithmetic; vector and matrix manipulation. Prerequisites: CS 31011 and CS 33001.
- 46201 **INTRODUCTION TO THE THEORY OF AUTOMATA, FORMAL LANGUAGES, & COMPUTATION (3)**
Alphabets, strings, languages; regular languages and expressions and finite automata; context-free grammars and languages and pushdown automata; Turing machines; fundamentals of computability theory. Prerequisites: MATH 12003 and CS 31011 and CS 31012.
- 47101 **COMPUTER GRAPHICS (3)**
Display file generation, interactive graphics techniques, display devices, three-dimensional graphics, graphic system design, graphic languages and applications in man-machine communications. Prerequisite: CS 33001, or permission.

- 49995 **SELECTED TOPICS IN COMPUTER SCIENCE & ITS APPLICATIONS (1-3)**
(repeated registration permitted)
Various special courses will be announced in the *Schedule of Classes* under this course number with different section numbers. Prerequisite: Permission of instructor.
- 49996 **INDIVIDUAL STUDY AND RESEARCH (1-3)**
Prerequisite: Permission.

MATHEMATICS

- 10005 **INTRODUCTION TO COLLEGE MATHEMATICS (3)**
Includes number systems, exponents, polynomials, the Cartesian coordinate system, linear and quadratic equations, and inequalities. Prerequisite: Appropriate placement test score or grade of "C" or better in A&S 10004.
- 10041 **ELEMENTARY PROBABILITY & STATISTICS (3)**
Descriptive statistics, probability concepts, binomial and normal distributions. Sampling, estimation, hypothesis testing. Analysis of paired data, linear models, and correlation. Prerequisite: MATH 10005 or appropriate placement test score.
- 11011 **COLLEGE ALGEBRA (4)**
Level of difficulty between that of MATH 10005 and 12001. Includes factoring, inequalities, functions, graphs, exponential and logarithmic functions. Prerequisites: MATH 10005 or appropriate placement test score; and no credit for MATH 12001.
- 11012 **INTUITIVE CALCULUS (3)**
Designed to give an overview of differential and integral calculus to business and life-science majors. Does not include trigonometric functions. Prerequisite: MATH 11011 or MATH 12001 or appropriate placement test score.

- 11022 **TRIGONOMETRY (2)**
 Solution of triangles, trigonometric equations, and identities. Prerequisite: MATH 11011 or appropriate placement test score and no credit for MATH 12001.
- 12001 **ALGEBRA AND TRIGONOMETRY (4)**
 Includes topics covered in MATH 11011 and MATH 11022. Prerequisites: MATH 10005 or appropriate placement test score; and no credit for MATH 11011.
- 12002 **ANALYTIC GEOMETRY & CALCULUS (5)**
 Concepts of limit, continuity, the derivative, and the indefinite and definite integral for functions of one real variable. Maximization, related rates. Fundamental Theorem of Calculus. Prerequisite: MATH 12001 or MATH 11022 or appropriate placement test score.
- 12003 **ANALYTIC GEOMETRY & CALCULUS II (5)**
 Continued study of techniques and applications of integration; trigonometric, logarithmic, and exponential functions; polar coordinates; vectors; parametric equations; sequences and series. Prerequisite: MATH 12002.
- 12021 **CALCULUS FOR LIFE SCIENCES (4)**
 Differential and integral calculus using examples and problems in life sciences. Prerequisite: ILS major or permission.
- 12022 **PROBABILITY & STATISTICS FOR LIFE SCIENCES (3)**
 Probability and statistics and applications in medical and biological sciences. Prerequisite: MATH 12021 or MATH 12003.
- 14001 **BASIC MATHEMATICAL CONCEPTS I (4)**
 Development of the real number system and its subsystems, open sentences, numeration systems, and some number theory concepts. Prerequisite: 10005 or appropriate placement test score.
- 14002 **BASIC MATHEMATICAL CONCEPTS II (3)**
 Basic concepts of modular arithmetics, probability, statistics, and geometry. Prerequisite: MATH 14001.
- 19099 **FIELD EXPERIENCE IN MATHEMATICS INSTRUCTION (1)**
 Learning through tutoring. A supervised lab experience in providing explanations of mathematical concepts. May be repeated in a different area. Prerequisite: Permission for one of the areas: algebra, trigonometry, mathematics education, or calculus.
- 21001 **LINEAR ALGEBRA WITH APPLICATIONS (3)**
 Systems of linear equations and the associated matrix operations, linear transformations, vector spaces, bases, eigenvectors. Prerequisite: MATH 11012 or MATH 12002.

- 21003 **INTRODUCTION TO SYSTEMS ANALYSIS AND DATA COMMUNICATIONS (3)**
 (cross-listed with Regional Campuses course COMT 21003
 — offered at Stark Campus only)
 Background in the topic of systems analysis, design, development, and implementation including an overview of teleprocessing. Prerequisite: ADMS 24002.
- 21092 **COMPUTER PRACTICUM (2)**
 (cross-listed with Regional Campuses course COMT 21092
 — offered at Stark Campus only)
 Supervised work experience in a computer installation.
- 22005 **ANALYTIC GEOMETRY & CALCULUS III (3)**
 Study of functions of several variables, including partial derivatives and multiple integrals. Prerequisite: MATH 12003.
- 30011 **BASIC PROBABILITY & STATISTICS (3)**
 Analysis and representation of data. Controlled experiments and observations. Measurement errors. Correlation and regression. Sampling. Probability models and tests of models. Inference. Prerequisite: MATH 11011 or MATH 12001.
- 31011 **DISCRETE MATHEMATICS I (3)**
 (cross-listed with CS 31011)
 Discrete mathematical techniques and structures including finite set theory, graph theory, propositional calculus, combinatorics, and discrete probability. Formal methodology and proof techniques. Prerequisites: MATH 12002 and MATH 21001 (concurrent registration in MATH 21001 allowed).
- 31012 **DISCRETE MATHEMATICS II (3)**
 (cross-listed with CS 32012)
 A continuation of Discrete Math I: emphasizing advanced combinatorial techniques such as partitions, graph applications in algorithms, and finite algebraic structures. Prerequisite: MATH 31011 or CS 31011.
- 31045 **FORMAL LOGIC (3)**
 See Department of Philosophy. Cannot be counted as mathematics credit toward a mathematics degree. Prerequisite: None.
- 34001 **FUNDAMENTAL CONCEPTS OF ALGEBRA (3)**
 Professionalized course in algebra for prospective secondary teachers. Postulational development of number systems of algebra; other systems, related topics, applications. Prerequisite: MATH 12002.
- 34002 **FUNDAMENTAL CONCEPTS OF GEOMETRY (3)**
 Professionalized course in geometry for secondary school teachers. Origin and development of the geometry of Euclid with modern refinements, topics, approaches. Other geometries, applications. Prerequisite: MATH 12002.
- 40011 **INTRODUCTION TO PROBABILITY THEORY AND APPLICATION (3)**
 Permutations and combinations, discrete and continuous distributions, random variables, conditional probabilities, Baye's formula, mathematical expectation, law of large numbers, normal approximations, basic limit theorems. Prerequisite: MATH 12003.
- 40012 **INTRODUCTION TO STATISTICAL CONCEPTS (3)**
 Sampling distributions, point and interval estimation, hypothesis testing, types of error, level and power of tests, sequential and nonparametric methods. Prerequisite: MATH 40011.

- 40022 **LINEAR MODELS & STATISTICAL ANALYSIS (3)**
 Regression model, multivariate normal distribution, point and interval estimates. Gauss-Markov Theorem, correlation and regression, tests of hypotheses, applications. Prerequisites: MATH 21001 and MATH 40012.
- 40031 **BASIC NONPARAMETRIC STATISTICS (3)**
 Rank tests for different kinds of hypothesis, large sample theory, efficiency comparisons, tests of Kolmogorov-Smirnov type. Prerequisite: MATH 40012.
- 40041 **SAMPLING, DESIGN & ANALYSIS OF EXPERIMENTS (3)**
 Normal equations and the F-statistic, analysis of variance, one-way and multi-way layouts, randomization, complete and incomplete designs, analysis of covariance. Prerequisites: MATH 21001 and MATH 40012.
- 40051 **TOPICS IN PROBABILITY THEORY & STOCHASTIC PROCESSES (3)**
 Topics from random walks, renewal theory, Markov processes, branching processes and birth-death processes. Brownian motion and other simple processes with applications. Prerequisite: MATH 40011.
- 40093 **VARIABLE TITLE WORKSHOP (2-6)**
 Studies special topics in mathematics. Not acceptable for credit toward a major or minor in math without approval of student's advisor. Prerequisite: Permission.
- 41001 **INTRODUCTION TO MODERN ALGEBRA I (3)**
 Basic properties of groups, subgroups, factor groups. Basic properties of rings, integral domains, and homomorphisms. Prerequisite: MATH 21001 and MATH 22005.
- 41002 **INTRODUCTION TO MODERN ALGEBRA II (3)**
 A continuation of MATH 41001: emphasizing properties of rings, their ideals, polynomial ring extensions, fields, finite degree extensions, roots of polynomials, constructibility. Prerequisite: MATH 41001 or permission.
- 41021 **THEORY OF MATRICES (3)**
 A rigorous study of the topics introduced in matrix algebra. Topics included are: vector space preliminaries, canonical forms of matrices, diagonalizability criteria. Prerequisite: MATH 21001 and MATH 22005 or permission.
- 41045 **METALOGIC (3)**
 (cross-listed with PHIL 41045). May be counted toward B.A. or B.S. mathematics major. Prerequisite: MATH 31045 or permission.
- 42001 **INTRODUCTION TO ANALYSIS I (3)**
 Topics include basic structure of the real numbers, Cauchy sequences, convergence, completeness of the real numbers, continuity, differentiation and Riemann integration. Prerequisites: MATH 21001 and MATH 22005.

- 42002 **INTRODUCTION TO ANALYSIS II (3)**
 Topics include further development of integration theory, infinite series, uniform convergence, several variable calculus and metric spaces. Prerequisite: MATH 42002.
- 42011 **MATHEMATICAL OPTIMIZATION (3)**
 Analytic and numerical techniques for location of extreme points of functions and calculus of variations. Both constrained and unconstrained problems are considered. Prerequisites: MATH 21001 and MATH 22005 or permission.
- 42021 **GRAPH THEORY AND COMBINATORICS (3)**
 Fundamentals and applications of combinatorial mathematics. Topics include traversability, colorability, networks, inclusion and exclusion, matching, and designs. Prerequisites: MATH 21001 and MATH 12003 or permission.
- 42031 **MATHEMATICAL MODELS (3)**
 Design and comparison of mathematical models. Numerous models from the physical, social, life, and management sciences are examined. Includes graphic methods and optimization techniques. Prerequisites: MATH 21001 and MATH 22005 or permission.
- 42044 **APPLIED ANALYSIS I (4)**
 Introduction to the theory and application of ordinary differential equations. Topics include variation of parameters, series solutions, and matrix methods for solving linear systems. Prerequisite: MATH 22005 and MATH 21001.
- 42045 **APPLIED ANALYSIS II (4)**
 Introduction to Fourier series and partial differential equations including the study of the wave, heat, and potential equations of mathematical physics. Prerequisite: MATH 42044
- 42048 **INTRODUCTION TO COMPLEX VARIABLES (3)**
 Algebra of complex numbers, analytic functions, mappings, Cauchy integral theory, residue theory, and applications. Prerequisite: MATH 22005.
- 42201 **INTRODUCTION TO NUMERICAL COMPUTING I (3)**
 (cross-listed with CS 42201)
 Numerical algorithms, recursion formulas, error analysis, interpolation, least squares approximation, data reduction, numerical linear algebra, solution of nonlinear equations, methods implemented using algorithmic programming language. Prerequisites: CS 10061, MATH 12003, and MATH 21001.
- 42202 **INTRODUCTION TO NUMERICAL COMPUTING II (3)**
 (cross-listed with CS 42202)
 Difference operators, difference equations, numerical integration and differentiation, extrapolation methods. Numerical solution of initial boundary, and eigenvalue problems for ordinary and partial differential equations. Prerequisites: MATH/CS 42201 and MATH 42044.
- 45011 **DIFFERENTIAL GEOMETRY (3)**
 Analytic and metric differential geometry of curves and surfaces. Prerequisite: MATH 22005.

- 45021 **EUCLIDEAN GEOMETRY (3)**
The geometry of Euclid extended to advanced topics of triangles, quadrilaterals and circles; cross-ratio, groups, constructions, geometric generalizations; inversion. Prerequisite: MATH 21001 or permission.
- 45022 **LINEAR GEOMETRY (3)**
Using transformations as a tool to study geometry and to differentiate between different kinds of geometry. Linear algebra methods applied to geometry. Prerequisite: MATH 21001 or permission.
- 46001 **ELEMENTARY TOPOLOGY (3)**
Metric spaces, introduction to topological spaces, separation axioms. Prerequisite: MATH 22005.
- 47001 **MATHEMATICAL LOGIC AND SET THEORY (3)**
Axiomatic set theory, relations, development of the real numbers, cardinal numbers, axiom of choice. Prerequisite: Permission.
- 47011 **THEORY OF NUMBERS (3)**
Divisibility properties of the integers, prime numbers, congruences, quadratic reciprocity, Diophantine equations, number theoretic functions, simple continued fractions, rational approximations. Prerequisite: MATH 12003 or permission.
- 47021 **HISTORY OF MATHEMATICS (3)**
A survey from Babylonian and Egyptian mathematics to twentieth-century mathematics with emphasis on the development of algebra, geometry, calculus, number theory. Prerequisite: Three hours of mathematics beyond 22005 or permission.
- 47095 **SELECTED TOPICS IN MATHEMATICS & ITS APPLICATIONS (1-4)**
Various special courses will be announced in the *Schedule of Classes* under this course number with different section numbers. Repeated registration permitted. Prerequisite: Permission.
- 47096 **INDIVIDUAL STUDY AND RESEARCH (1-3)** Prerequisite: Permission.
-