Mathematics and Computer Science

General Information

Degrees and Areas of Concentration

The Department of Mathematics and Computer Science offers undergraduate and graduate degree programs, minors, and certificates.

At the undergraduate level, the department offers work leading to the Bachelor of Arts (B.A.) in mathematics, the Bachelor of Science (B.S.) in mathematics, the B.S. in computer science, and, in cooperation with the College of Education, the Bachelor of Secondary Education (B.S.Ed.) in secondary education with an emphasis in mathematics. The department also offers minors in computer science, mathematics, and statistics, a Certificate in Actuarial Studies, a Certificate in Internet and Web, a Certificate in Mobile and Ubiquitous Computing, and in cooperation with the Department of Information Systems a joint Certificate in Cybersecurity.

At the graduate level, the department offers a Master of Arts (M.A.) degree in mathematics, a Master of Science (M.S.) degree in computer science and a Doctor of Philosophy (Ph.D.) in mathematical and computational sciences — with options in mathematics, computer science, and statistics. The department also offers, in cooperation with the Department of Information Systems, a joint Certificate in Cybersecurity.

Undergraduate Programs Overview

The program leading to the B.A. in mathematics provides a broad grounding in different areas of mathematics, giving students the depth necessary to pursue various aims such as graduate studies or other career choices.

The B.S. in mathematics provides a substantial background in mathematics, statistics and computer science to produce graduates who can work as mathematicians. Both the B.A. and the B.S. in mathematics allow optional courses that enable the student to focus on areas of interest like pure or applied mathematics. Students pursuing the B.A. or the B.S. in mathematics will graduate with analytic and writing skills in mathematics and will have knowledge of content in core areas of the subject. They will have been exposed to applications of mathematics and they will possess critical thinking and quantitative skills.

The B.S.Ed. in secondary education with an emphasis in mathematics introduces students to those branches of mathematics most relevant to the teaching of secondary school mathematics.

The B.S. in computer science curriculum provides a firm foundation for both more traditional computer science as well as for the technical aspects of the emerging information technology areas. This is accomplished through fundamental courses in mathematics and statistics, a rigorous list of core computer science courses, as well as by emphasizing written and oral communication skills, problem solving, and exposure to modern technology. In addition, the program offers a variety of interest specific electives focusing on graphics, image processing, AI, database systems, networking, cybersecurity, object-oriented and web-based technology, and mobile computing. Undergraduate students can also complete any of the undergraduate certificates as part of their program. Given the ever-widening impact of digital technology on daily life, our Computer Science graduates enjoy significant employment opportunities.

The Certificate in Internet and Web is designed to provide a broad training in technologies related to the Internet and Web, with flexibility allowing a student to satisfy specific interests.

The Certificate in Mobile and Ubiquitous Computing is designed to provide training in technologies and framework for mobile apps and computing.

The joint Certificate in Cybersecurity is designed to provide basic training in emerging areas of information, data, and network security.

Graduate Programs Overview

Dual Programs

The Department offers dual degree programs in mathematics and computer science for students with strong academic records. The B.A./B.S. and M.A. dual degree program in mathematics and the B.S./M.S. dual degree program in computer science are designed to provide an opportunity for strong undergraduate majors to start earning graduate work credit before actually completing their undergraduate degree and to shorten, or accelerate, the time required as students to earn their graduate degrees.

Graduate Programs Overview

Students pursuing the M.A. degree in mathematics may choose an emphasis in either pure or applied mathematics. The pure mathematics emphasis is well suited for students preparing to teach at the high school, junior college, or four year liberal arts college level. Those who concentrate on applied courses in the M.A. program build a foundation for the application of mathematics in industry and the continuation of their education in the Ph.D. program in mathematical and computational sciences. Our graduates will have abilities in the basic areas of mathematics, and a breadth of knowledge in core subjects at the graduate level. They will study at least one area of mathematics or statistics in depth and will understand some of the contemporary research in applied mathematics and statistics. They will develop the ability to prepare and deliver oral and written presentations and the ability to pursue mathematical knowledge independently.

The M.S. degree in computer science emphasizes practical aspects of the field. Our graduates will have good understanding of the software process and its challenges, good understanding of computers systems and its parts, and be exposed to a wide range of technologies. They will also be prepared for team work, independent research, and technical reporting and presentations.

The Ph.D. program in mathematical and computational sciences has options in mathematics, computer science, and statistics. The mathematics and statistics options prepare students for a leadership role involving research and development in both industrial and academic settings. Students choosing one of these options will develop abilities in the basic areas of algebra, analysis, and geometry, and will possess breadth of knowledge in core subjects at the graduate level. They will study at least one area of mathematics or statistics in depth and will understand contemporary research in applied mathematics and statistics. They will develop the ability to prepare and deliver oral and written presentations, and they will possess the ability to pursue and produce mathematical or statistical knowledge independently.

Students choosing the computer science option will develop a breadth of abilities in the core areas of computer science at the graduate level. They will gain a depth of ability in contemporary research in their chosen
subfield of computer science, and will be able to pursue independent research in their area of specialization.

Students may enroll in any of these graduate programs on a part-time basis.

**Career Outlook**

A degree in mathematics or computer science prepares well-motivated students for interesting careers. Our graduates find positions in industry, government, and education. The demand for individuals well trained in statistics, computer science, and mathematics is greater than the available supply. In addition, a number of graduates in mathematics have elected careers in business, law and other related fields where they find logical and analytical skills valuable.

Graduates in computer science and mathematics from UMSL are located throughout the country, and they also have a strong local presence. They have careers in banking, health care, engineering and manufacturing, law, finance, public service, management, and actuarial management. Many are working in areas such as systems management, information systems and data management, scientific computing, and scientific positions in the armed services. Others have careers in education, especially at secondary and higher levels.

**Department Scholarships**

The Department of Mathematics and Computer Science offers many merit and need based scholarships available to department majors.

The Alumni Scholarship is a monetary award for outstanding undergraduate students open to all junior and senior department majors.

The Edward Z. Andalafte Memorial Scholarship is a monetary award for outstanding undergraduate department majors at the sophomore level or higher.

The Raymond and Thelma Balbes Scholarship in Mathematics is a monetary award for students at the sophomore level or higher who are pursuing a degree in mathematics, have an overall GPA of at least 3.0 and a GPA of at least 3.2 in mathematics and who have completed three semesters of calculus.

The Joseph M. and Mary A. Vogl Scholarship in Mathematics is a need based monetary award for mathematics majors.

The Computer Science Scholarship is a monetary award for outstanding computer science majors with preference given to freshman and sophomore students. Applicants must have a grade point average of 3.5 or higher in courses taken in the department.

The Boeing Company Scholars Program in Computer Science is a monetary award for full-time (at least 12 hours) upper-level undergraduate students in computer science. Recipients must have a minimum GPA of 3.2 and must maintain a GPA of 3.0. Preference will be given to traditionally underrepresented populations.

**Undergraduate Studies**

**General Education Requirements**

All majors must satisfy the university and appropriate school or college general education requirements (http://bulletin.umsl.edu/generaleducationrequirements). All mathematics courses may be used to meet the university’s general education breadth of study requirement in natural sciences and mathematics.

**Satisfactory/Unsatisfactory Restrictions**

Majors in mathematics and computer science may not take mathematical sciences or related area courses on a satisfactory/unsatisfactory basis. Students considering graduate study should consult with their advisers about taking work on a satisfactory/unsatisfactory basis.

**Degree Requirements**

All mathematical sciences courses presented to meet the degree requirements must be completed with a grade of C- or better. At least four courses numbered 3000 or above must be taken in residence. Students must have a 2.0 grade point average in the mathematical sciences courses completed.

Students enrolling in introductory mathematics courses should check the prerequisites to determine if a satisfactory score on the Mathematics Placement Test is necessary. The dates on which this test is administered are given on the department’s website. Placement into introductory courses assumes a mastery of two years of high school algebra.

A minimum grade of C- is required to meet the prerequisite requirement for any course except with permission of the department.

Note: Courses that are prerequisites for higher-level courses may not be taken for credit or quality points if the higher-level course has been satisfactorily completed.

Many students are qualified, as a result of having studied calculus in high school, to begin their major with MATH 1900 (p. 1), Analytic Geometry and Calculus II, or MATH 2000 (p. 1), Analytic Geometry and Calculus III. These students are urged to consult with the department before planning their programs. Credit for MATH 1800 (p. 1), Analytic Geometry and Calculus I, will be granted to those students who complete MATH 1900 (p. 1) with a grade of C- or better.

Similarly, students who are ready to begin their computer science studies with CMP SCI 2250 (p. 1), Programming and Data Structures, will be granted credit for CMP SCI 1250 (p. 1), Introduction to Computing, once they complete CMP SCI 2250 (p. 1) with a grade of C- or better.

**Declaring the Mathematics Major**

Students seeking to major in mathematics are first designated as “pre-mathematics majors” until they have completed both MATH 1900 and MATH 2000 or equivalent courses. Upon successful completion of these two courses with grades of C or better, students will be allowed to declare mathematics as their major. Each of these courses must be completed successfully within two attempts.

**Degree Requirements in Mathematics**

All mathematics majors in all undergraduate programs must complete the mathematics core requirements.

**Core Requirements**

1. The following courses are required:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMP SCI 1250</td>
<td>Introduction To Computing</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1320</td>
<td>Applied Statistics I</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1800</td>
<td>Analytic Geometry And Calculus I</td>
<td>5</td>
</tr>
<tr>
<td>MATH 1900</td>
<td>Analytic Geometry And Calculus II</td>
<td>5</td>
</tr>
</tbody>
</table>
Bachelor of Arts in Mathematics.

In addition to the core requirements and the College of Arts and Sciences' foreign language requirement, three mathematics courses at the 4000 level or higher must be completed. Of these, one must be MATH 4400 (p. 1), Introduction to Abstract Algebra.

B.S.Ed. in Secondary Education with emphasis in mathematics.

In addition to the core requirements and the required education courses, three mathematics/statistics courses at the 4000 level or higher must be completed.

Of these, one must be, Introduction to Abstract Algebra, and one must be chosen from:

- MATH 4660 (p. 1), Foundations of Geometry or MATH 4670 (p. 1), Introduction to Non-Euclidean Geometry

Bachelor of Science in Mathematics

In addition to the core requirements, the B.S. in Mathematics degree requires:

1. Completing all of the following:
   - MATH 4160, Complex Analysis I (p. 1) 3
   - MATH 4400, Introduction to Abstract Algebra I (p. 1) 3
   - MATH 4450, Linear Algebra (p. 1) 3

   Total Hours 9

2. Completing an additional three courses numbered above 4000 in mathematics, statistics or computer science, at least one of which must be in mathematics/statistics.

Related Area Requirements for majors in Mathematics

Candidates for the B.A. in Mathematics must satisfy the requirements in one of the groups below with a grade of C-or better. Candidates for the B.S.Ed. in Mathematics and B.S. in Mathematics must satisfy the requirements in two of the groups below with a grade of C-or better.

If candidates choose group 2, then they cannot apply either of the two courses listed in that group towards the additional 4000 level mathematics courses (beyond the core requirements) that must be completed for each of these degrees.

Students seeking a double degree, either within this department or with another department do not have to fulfill the related area requirements.

Related Area Courses

1) Computer Science
- Select two of the following:
  - CMP SCI 2250 Programming And Data Structures
  - CMP SCI 2700 Computer Organization and Architecture
  - CMP SCI 3130 Design And Analysis Of Algorithms
  - CMP SCI 4140 Theory Of Computation
  - CMP SCI 4410 Computer Graphics
  - CMP SCI 4420 Introduction to Digital Image Processing

2) Statistics
- MATH 4200 Mathematical Statistics I 3
- MATH 4210 Mathematical Statistics II 3

3) Biology
- BIOL 2102 General Ecology 3
- BIOL 2103 General Ecology Laboratory 2

4) Biology
- BIOL 2012 Genetics 3
- BIOL 4182 Population Biology 3

5) Chemistry
- CHEM 1111 Introductory Chemistry I 5
- CHEM 1121 Introductory Chemistry II 5

6) Chemistry
- CHEM 3312 Physical Chemistry I 3
  And another 3000-level, or above, chemistry course. 3

7) Economics
- ECON 1001 Principles Of Microeconomics 3
- ECON 1002 Principles Of Macroeconomics 3
- ECON 4100 Introduction To Econometrics 4

8) Philosophy
- PHIL 3360 Formal Logic 3
- PHIL 3380 Philosophy Of Science 3
- PHIL 4460 Advanced Formal Logic 3

9) Physics
- PHYSICS 2111 Physics: Mechanics And Heat 5
- PHYSICS 2112 Physics: Electricity, Magnetism, And Optics 5

10) Physics
- PHYSICS 3221 Mechanics 3
  And another 3000 level, or above, physics course. 3

11) Business Administration
- LOG OM 3320 Introduction To Operations Management 3
  and one of the following courses:
  - LOG OM 4321 Production and Operations Management 3
  - LOG OM 4326 Quality Assurance In Business 3
  - LOG OM 4330 Business Logistics Systems 3
  - LOG OM 4350 Management Science Methods 3

12) Engineering
Declaring the Computer Science Major

Students seeking to major in computer science are first designated as “pre-computer science majors” until they have completed CMP SCI 2750 or equivalent course. Upon successful completion of this course with a grade of C- or better, students will be allowed to declare computer science as their major. This course must be completed successfully within two attempts.

Degree Requirements in Computer Science

Candidates for the B. S. Computer Science degree must complete the following work:

1) Computer Science Core
   - CMP SCI 1250 Introduction To Computing 3
   - CMP SCI 2250 Programming And Data Structures 3
   - CMP SCI 2261 Object-Oriented Programming 3
   - CMP SCI 2700 Computer Organization and Architecture 3
   - CMP SCI 2750 System Programming and Tools 3
   - CMP SCI 3010 Web Programming 3
   - CMP SCI 3130 Design and Analysis of Algorithms 3
   - CMP SCI 4250 Programming Languages 3
   - CMP SCI 4280 Program Translation 3
   - CMP SCI 4500 Introduction to the Software Profession 3
   - CMP SCI 4760 Operating Systems 3

2) Computer Science Electives
   Select five more elective computer science courses, numbered above 3000. 15

3) Mathematics and Statistics
   - MATH 1320 Applied Statistics I 3
   - MATH 1800 Analytic Geometry And Calculus I 5
   - MATH 1900 Analytic Geometry And Calculus II 5
   - MATH 2450 Elementary Linear Algebra 3
   - MATH 3000 Discrete Structures 3

4) Additional Skills
   - ENGL 3130 Technical Writing 3

Total Hours 70

BS and MS Dual Degree in Computer Science

The Integrated BS/MS (“2+3”) dual degree program involves dual credit for qualified undergraduate Computer Science students. It allows the students to concurrently earn credit for some graduate courses while working on their undergraduate degree, reducing the total hours needed for the subsequent MS degree by up to 12 credit hours.

Entry Requirements

Undergraduate majors can apply for provisional admission to this program if:

1. They have completed at least 60 credit hours of coursework.
2. Their overall GPA is 3.0 or higher.
3. Non-CS majors must at the same time become CS majors.

Upon acceptance to the program in the provisional status, the student continues to work toward his/her undergraduate degree in computer science.

After completion of a minimum of 90 hours and no more than 30 hours away from the undergraduate degree, a provisionally admitted student applies for formal admission to the graduate program. At this point, the student must meet the entry requirements for admission to the M.S. degree in Computer Science.

Degree Requirements

After acceptance into the program, the student continues to complete his/her undergraduate degree. The student is reclassified as a graduate student from the next semester and must pay graduate fees. The student will be assigned a graduate adviser to help optimize the transition to the graduate program. The student continues taking the undergraduate courses but is also allowed to take courses reserved for graduate students. The student completes all the courses to fulfill the requirements to complete his/her M.S. degree in Computer Science – but must also complete the undergraduate requirements. Up to 12 credit hours can be counted towards both the undergraduate and graduate degrees, substantially reducing the hours needed to complete the graduate program by itself.

A student may file for and receive the undergraduate degree at any time when all the requirements are completed, before or in the same semester in which the Master's degree is completed. A student must still complete all the requirements to get a B.S. degree, regardless of whether the student files for the degree or not. A student may choose to finish the studies just with a B.S.

Minor Requirements

The department offers minors in computer science, mathematics, and statistics. All courses presented for any of these minors must be completed with a grade of C- or better.

Minor in Computer Science

The requirements for the minor are:

- CMP SCI 1250 Introduction To Computing 3
- CMP SCI 2250 Programming And Data Structures 3
- Select three additional computer science courses numbered 2000 or above. 9

Total Hours 15

A minimum of two computer science courses numbered above 2000 must be taken in residence in the Department of Mathematics and Computer Science at UMSL.

Minor in Mathematics

The requirements for the minor are:

- MATH 1800 Analytic Geometry And Calculus I 5
Certificate in Internet and Web
(pending CBHE approval)

The undergraduate Certificate in Internet and Web is a six-course (18 credit hours) program. It is designed to provide a broad training in technologies related to the Internet and Web, with flexibility allowing a student to satisfy specific interests. A minimum GPA of 2.5 is required for admission.

**Required:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMP SCI 3010</td>
<td>Web Programming</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 4010</td>
<td>Advanced Web Development with Java</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 4012</td>
<td>Introduction to Enterprise Web Development</td>
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</tr>
</tbody>
</table>

**Choose three of the following:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMP SCI 4020</td>
<td>Introduction to Android Apps: Android Fundamentals</td>
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</tr>
<tr>
<td>CMP SCI 4030</td>
<td>Introduction to Intelligent Web</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 4610</td>
<td>Database Management Systems</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 4730</td>
<td>Computer Networks and Communications</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 4750</td>
<td>Introduction to Cloud Computing</td>
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</tr>
<tr>
<td>INFSYS 3846</td>
<td>E-Commerce</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Hours**

27

A minimum of four courses must be taken in residence at UMSL. Courses may be substituted with the permission of the department. For more information, students can contact the department chair or email info@arch.umsl.edu.

Certificate in Mobile and Ubiquitous Computing
(pending CBHE approval)

The undergraduate Certificate in Mobile and Ubiquitous Computing is a six-course (18 credit hours) program. It is designed to provide training in technologies and framework for mobile apps and computing. A minimum GPA of 2.5 is required for admission.

**Required Courses:**

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<td></td>
</tr>
<tr>
<td>CMP SCI 4220</td>
<td>Introduction to iOS Programming and Apps</td>
<td></td>
</tr>
<tr>
<td>CMP SCI 4222</td>
<td>iOS Apps</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 4710</td>
<td>Mobile And Ubiquitous Computing</td>
<td></td>
</tr>
</tbody>
</table>

**Choose one of the following:**

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<th>Credits</th>
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</thead>
<tbody>
<tr>
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<td>Advanced Web Development with Java</td>
<td></td>
</tr>
<tr>
<td>CMP SCI 4610</td>
<td>Database Management Systems</td>
<td></td>
</tr>
<tr>
<td>CMP SCI 4750</td>
<td>Introduction to Cloud Computing</td>
<td></td>
</tr>
</tbody>
</table>

A minimum of four courses must be taken in residence in the Department of Mathematics and Computer Science at UMSL. Courses may be substituted with the permission of the department. For more information, students can contact the department chair or email info@arch.umsl.edu.

Graduate Studies

The Department of Mathematics and Computer Science offers an M.A. degree in mathematics, a Ph.D. degree in mathematical and
computational sciences (with options in mathematics, computer science, and statistics), and an M.S. degree in computer science.

Admission
Applicants must meet the general admission requirements of the Graduate School, described elsewhere in this Bulletin. Additional admission requirements for specific programs are listed below.

Mathematics Programs
Applicants must have at least a bachelor's degree in mathematics or in a field with significant mathematical content. Examples of such fields include computer science, economics, engineering and physics. An applicant’s record should demonstrate superior achievement in undergraduate mathematics.

Individuals may apply for direct admission to either the M.A. or Ph.D. program. Candidates for the M.A. degree may choose to concentrate in either pure or applied mathematics. Students in the M.A. program who want to transfer to the Ph.D. program upon successful completion of 15 credit hours must fill out a new application through Graduate Admissions.

Students intending to enter the Ph.D. program must have a working ability in modern programming technologies. A student with a deficiency in this area may be required to take courses at the undergraduate level in computer science.

Applicants for the Ph.D. program must, in addition, submit three letters of recommendation and scores from the Graduate Record Examination (GRE) general aptitude test.

Computer Science Programs
Applicants must have at least a bachelor's degree, preferably in computer science or in a related area. Applicants with bachelor's degrees outside of computer science must demonstrate significant proficiency in computer science by showing competence (proving related academic or professional experience, or taking a test) in the following areas. Courses in parenthesis are UMSL courses that can be used to fulfill the requirement.

Programming skills in C or C++ and Java (CMP SCI 1250 or CMP SCI 2250, and CMP SCI 2261)
Proficiency with Object-Oriented concepts and terminology (CMP SCI 2261)
Proficiency with dynamic data structures (CMP SCI 2250)
Proficiency with computer organization, architecture, or assembly level programming (CMP SCI 2700)
Proficiency with design and time/space analysis of algorithms (CMP SCI 3130)
Familiarity with Unix/Linux/OSX and with command-line scripting with tools (CMP SCI 2750)
Students must also have satisfactorily completed mathematics courses equivalent to the following UMSL courses:
Two semesters of calculus (MATH 1800 and MATH 1900)
A course in elementary linear algebra (MATH 2450)
A course in discrete mathematics (MATH 3000)

An elementary course in probability or statistics (MATH 1320)
A student missing some of the above requirements may be admitted on restricted status if there is strong supportive evidence in other areas. The student will have to take the missing courses, or otherwise demonstrate proficiency. Special regulations of the Graduate School that apply to students on restricted status are described in the UMSL Bulletin.

Preliminary Advisement
Incoming students are assigned advisers with whom they should consult before each registration period to determine an appropriate course of study. If necessary, students may be required to complete undergraduate course work without receiving graduate credit.

Students interested in the Ph.D. program in applied mathematics with the computer science option must follow the requirements for that program and that option.

Degree Requirements
Master of Arts in Mathematics
Candidates for the M.A. degree must complete 30 hours of course work. All courses numbered below 5000 must be completed with grades of at least B. The courses taken must include those listed below in group A together with additional courses discussed in B.

Students who have already completed courses equivalent to those in A) may substitute other courses numbered above 4000. All substitutions of courses for those listed in A) require the prior approval of the graduate director.

A. Mathematics core:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 4100</td>
<td>Real Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>MATH 4160</td>
<td>Complex Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>MATH 4450</td>
<td>Linear Algebra</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Hours: 9

B. M.A. candidates must also complete 15 hours of course work numbered 5000 or above, chosen with the prior approval of the graduate director. Courses may be chosen to develop expertise in either pure or applied mathematics.

Thesis Option
Part of B) may consist of an M.A. thesis written under the direction of a faculty member in the Department of Mathematics and Computer Science. A thesis is not, however, required for this degree. A student who wishes to write a thesis should enroll in 6 hours of MATH 6900 (p. 1). M.A. Thesis. Students writing an M.A. thesis must defend their thesis in an oral exam administered by a committee of three department members which includes the thesis director.

BA/BS and MA Dual Degree Program in Mathematics
This is an integrated BA/BS and MA ("2+3") dual degree program in Mathematics: it is designed to provide an opportunity for mathematics majors at the University of Missouri-St Louis (UMSL) with a strong
Students must satisfy all of the following core requirements:

related course work is allowed upon permission of the Graduate Director. With grades of at least B-.
Outside computer science, up to 6 hours of
Graduate Director. All courses numbered below 5000 must be completed
one course numbered 6000 or above, chosen with the prior approval of the
these, at least 18 hours must be numbered 5000 or above, with at least
hours of course work, subject to the Graduate School regulations. Of
Candidates for the M.S. degree in Computer Science must complete 30
Master of Science in Computer Science
Degree Program
for admission by the graduate committee.
accompanying the application is approved, the student needs to complete a formal
graduate committee will review the application and make a decision. In
mean the student is automatically admitted to this program. The math
A student’s application meeting the minimal requirements does not
mean the student is automatically admitted to this program. The math
graduate committee will review the application and make a decision. In
In the case the application is approved, the student needs to complete a formal
application for admission into the graduate program and is recommended for
admission by the graduate committee.
Degree Program
1. The current separate requirements for BA/BS and MA in math remain
unchanged.
2. Once the student is admitted in this program, the student is allowed to
take graduate courses (paid with graduate fees).
3. The student in this program can apply up to 12 credit hours of 4000-
and-above level courses towards both the bachelor and master’s
degrees. The student may get the BA/BS and MA degrees at the same
time.
4. In case a student cannot complete the master’s degree for some
reason, up to 12 credit hours of graduate level courses can be applied
towards the BA/BS degree.
5. Students will pay graduate fees for all courses after being admitted
and starting the program.

Master of Science in Computer Science
Candidates for the M.S. degree in Computer Science must complete 30
hours of course work, subject to the Graduate School regulations. Of
these, at least 18 hours must be numbered 5000 or above, with at least
one course numbered 6000 or above, chosen with the prior approval of the
Graduate Director. All courses numbered below 5000 must be completed
with grades of at least B-. Outside computer science, up to 6 hours of
related course work is allowed upon permission of the Graduate Director.

Students must satisfy all of the following core requirements:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMP SCI 4760</td>
<td>Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 4250</td>
<td>Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 5700</td>
<td>Computer Systems</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 5500</td>
<td>Software Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 5130</td>
<td>Advanced Data Structures And Algorithms</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Hours: 15

Waiving or substituting for a specific requirement can be done on the
basis of prior course work or experience at the discretion of the Graduate
Director, but it will not reduce the total hours required for the degree.
Additionally, students must attend at least five different seminars or
colloquium presentations in the department.

Thesis Option
Students may choose to write an M.S. thesis under the direction of a
faculty member in the Department of Mathematics and Computer Science.
A thesis is not, however, required for this degree. A student who wishes to
write a thesis should enroll in 6 hours of CMP SCI 6900 (p. 1), Thesis.
Students writing an M.S. thesis must defend their thesis in an oral exam
administered by a committee of three department members which includes
the thesis director.

Doctor of Philosophy in Mathematical and Computational Sciences
(pending CBHE approval)
The program has three options:

1. Mathematics Option
2. Computer Science Option
3. Statistics Option (pending CBHE approval)
The requirements for the Ph.D. degree include the following:

1. Course work
2. Ph.D. candidacy
3. Doctoral dissertation

The requirements are described in detail below.

1. Course Work
A minimum of 60 hours of courses numbered 4000 or above.
In the Mathematics Option, at least 33 hours must be in courses numbered
5000 or above.
In the Computer Science Option, at least 45 hours must be in courses numbered
5000 or above.
In the Statistics Option, at least 33 hours must be in courses numbered
5000 or above.
At most 9 hours of a student’s enrollment in MATH 7990 (Dissertation Research) may be counted. Students are expected to maintain a 3.0 average on a 4.0 scale. All courses numbered below 5000 must be completed with a grade of at least B. Courses outside the Department of Mathematics and Computer Science will require approval of the graduate director.

When students who have earned a Master’s degree are admitted to the
doctoral program, appropriate credits of course work may be applied...
toward meeting the requirements for the doctoral degree, subject to Graduate School regulations and the approval of the graduate director. The same applied to those with some appropriate graduate credits but without a completed Master's degree.

2. Ph.D. Candidacy
Advancement to Ph.D. candidacy is a three-step process consisting of:

1. Completing 18 hours of 5000 level courses other than MATH 7990, Ph.D. Dissertation Research.
2. Passing the comprehensive examination.
3. Selecting a Ph.D. committee and preparing a dissertation proposal and defense of the proposal.

Qualifying Examination
A student must fulfill the following requirements.

Basic Requirement
Pass one written examination covering fundamental topics. This examination would normally take place within the first 12 credit hours of study after admission to the Ph.D. program.

Mathematics Option
Topics from real analysis, complex analysis, and linear algebra:

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>MATH 4100</td>
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<td>MATH 4160</td>
<td>Complex Analysis I</td>
<td>3</td>
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Computer Science Option
Topics from the theory of programming languages, operating systems, analysis of algorithms, and computer systems:

<table>
<thead>
<tr>
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<th>Title</th>
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<tbody>
<tr>
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<td>Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>CMP SCI 4760</td>
<td>Operating Systems</td>
<td>3</td>
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<td>CMP SCI 5130</td>
<td>Advanced Data Structures And Algorithms</td>
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<td>CMP SCI 5700</td>
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Statistics Option
Topics from real analysis, linear algebra, and mathematical statistics:

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<tr>
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<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 4100</td>
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<td>MATH 4450</td>
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Additional Requirement
After fulfilling the basic requirement above, the student must meet one of the following:

1. Pass a written examination in an area of the student's interests. This area will be approved by the graduate committee and will be based on a set of two or more graduate courses taken by the student. This examination would normally take place within the first 24 credit hours of study after admission to the Ph.D. program.

2. Write a survey paper in a specialized area under the direction of a member of the graduate faculty. The student should propose to take this option when he/she has already finished at least 2 graduate level courses and has the approval of the graduate committee. The paper should be submitted within four semesters, at which time an oral examination given by a committee of at least three members of the graduate faculty must be passed.

In both parts 1) and 2), the graduate committee will determine if the topics are consistent with the option that the student is pursuing.

Dissertation Committee and Dissertation Proposal
After completing the comprehensive examinations, each student chooses a dissertation advisor and prepares a Dissertation Proposal. Usually students choose an advisor from contacts made through their course work. The dissertation committee will be formed, and the student will meet with this committee for an oral defense of his/her dissertation proposal. The dissertation proposal is a substantial document describing the problem to be worked on and the methods to be used, as well as demonstrating the student's proficiency in written communication.

Doctoral Dissertation
Each Ph.D. candidate must write a dissertation that is an original contribution to the field on a topic approved by the candidate's Ph.D. Committee and the department, and which meets the standards and requirements set by the Graduate School including the public defense of the dissertation. Students working on a dissertation may enroll in MATH 7990, Ph.D. Dissertation Research. A maximum of 9 hours in MATH 7990 can be used toward the required hours of work in courses numbered 5000 or above.

BS and MS Dual Degree in Computer Science
The Integrated BS/MS ("2+3") dual degree program involves dual credit for qualified undergraduate Computer Science students. It allows the students to concurrently earn credit for some graduate courses while working on their undergraduate degree, reducing the total hours needed for the subsequent MS degree by up to 12 credit hours.

Entry Requirements
Undergraduate majors can apply for provisional admission to this program if:

1. They have completed at least 60 credit hours of coursework.
2. Their overall GPA is 3.0 or higher.
3. Non-CS majors must at the same time become CS majors.

Upon acceptance to the program in the provisional status, the student continues to work toward his/her undergraduate degree in computer science. After completion of a minimum of 90 hours and no more than 30 hours away from the undergraduate degree, a provisionally admitted student applies for formal admission to the graduate program. At this point, the student must meet the entry requirements for admission to the M.S. degree in Computer Science.

Degree Requirements
After acceptance into the program, the student continues to complete his/her undergraduate degree. The student is reclassified as a graduate student from the next semester and must pay graduate fees. The student will be assigned a graduate adviser to help optimize the transition to the graduate program. The student continues taking the undergraduate courses but is also allowed to take courses reserved for graduate students. The student completes all the courses to fulfill the requirements to complete his/her M.S. degree in Computer Science – but must also complete the undergraduate requirements. Up to 12 credit hours can be counted towards both the undergraduate and graduate degrees, substantially reducing the hours needed to complete the graduate program by itself.

A student may file for and receive the undergraduate degree at any time when all the requirements are completed, before or in the same semester in which the Master's degree is completed. A student must still complete all the requirements to get a B.S. degree, regardless of whether the student files for the degree or not. A student may choose to finish the studies just with a B.S.

### Financial Assistance

Any student who intends to apply for financial assistance, in the form of a teaching assistantship or a research assistantship, is required to have three letters of recommendation submitted with the application to the graduate program in Mathematics or Computer Science. The application must include scores on the GRE general aptitude test. Applicants are also encouraged to submit scores in the GRE subject area test in Mathematics or Computer Science. Applications for financial assistance should be submitted before February 15 prior to the academic year in which the student expects to begin graduate study. Notifications of awards are generally made March 15, and students awarded financial assistance are expected to return letters of acceptance by April 15.

### Sample Four Year Plans

Mathematics BA (p. 9) Mathematics BS (p. 9) Computer Science BS (p. 10)

#### Mathematics BA

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<tr>
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</table>

¹ INTDSC 1003 is required only for first-time freshmen and transfer students with less than 24 college credits.

**Please Note:** This plan is an example of what a four year plan could look like for a typical student. Placement exam scores in math as well as the completion of coursework may change the plan. It should not be used in the place of regular academic advising appointments. All students are encouraged to meet with their advisor each semester. All requirements are subject to change.
encouraged to meet with their advisor each semester. All requirements are subject to change.

Computer Science BS

First Year

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<th>Hours</th>
<th>Spring</th>
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<tbody>
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Second Year

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Third Year

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Fourth Year

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Total Hours: 121-123

1 INTDSC 1003 is required only for first-time freshmen and transfer students with less than 24 college credits.

Please Note: This plan is an example of what a four year plan could look like for a typical student. Placement exam scores in math as well as the completion of coursework may change the plan. It should not be used in the place of regular academic advising appointments. All students are encouraged to meet with their advisor each semester. All requirements are subject to change.

Computer Science Courses

CMP SCI 1012 Learning to Program Using Virtual Worlds: 3 semester hours
Prerequisite: CMP SCI 1250. Provides an introduction to the concepts of computation, problem solving, and computer systems. Covers fundamental programming constructs, basic data types, and modularization using a modern high level language. Problem solving skills are developed through a progression of programming projects.

CMP SCI 1250 Introduction To Computing: 3 semester hours
Prerequisite: MATH 1030 with B-or better, or MATH 1100, or MATH 1800. Provides an introduction to the concepts of computation, problem solving, and computer systems. Covers fundamental programming constructs, basic data types, and modularization using a modern high level language. Problem solving skills are developed through a progression of programming projects.

CMP SCI 2250 Programming And Data Structures: 3 semester hours
Prerequisite: CMP SCI 1250. Continuation of CMP SCI 1250. Discusses properties and implementation of abstract data types such as lists, trees, stacks and queues. Introduces procedural and class abstraction, basic program architecture, use of interfaces, modular programming, and file processing.

CMP SCI 2261 Object-Oriented Programming: 3 semester hours
Prerequisite: CMP SCI 2250. Introduces object-oriented concepts, terminology, and notation (UML) using Java. Covers encapsulation, classes, objects, inheritance, and the use of class libraries. Additional topics may include graphical user interfaces, applets, and related tools and technologies.

CMP SCI 2700 Computer Organization and Architecture: 3 semester hours
Prerequisite: CMP SCI 2250. Introduces details of computer systems from architectural and organizational points of view. Covers data representation, basic digital logic circuits, memory types and hierarchies, I/O and storage devices, CPU architectures such as RISC, CISC, parallel, and multi-core.

CMP SCI 2750 System Programming and Tools: 3 semester hours
Prerequisites: CMP SCI 2250. Covers systems programming, scripting, libraries, utilities, and development tools. Additional programming topics include piping, binary files, exception handling, command-line arguments and symbolic debugging. This course also explores tools available in the Unix/Linux environments.

CMP SCI 3010 Web Programming: 3 semester hours
Prerequisite: CMP SCI 2250. Provides a survey of current Web technologies including markup languages (such as HTML/XHTML, CSS, XML), client side languages (such as JavaScript), server side languages (such as PERL, PHP), and Web protocols. This course requires client-server computing projects.
**CMP SCI 3130 Design and Analysis of Algorithms: 3 semester hours**
Prerequisites: CMP SCI 2250, MATH 1320, and MATH 3000. This course addresses the design and analysis of fundamental algorithms in computer science. Studies basic sorting algorithms, priority queues, order statistics, search trees, and hash tables. Analysis techniques may involve time and space complexity analysis of both iterative and recursive algorithms, analysis of algorithm correctness, and amortized complexity analysis. Additional topics may include data compression, string manipulation, greedy algorithms, dynamic programming, and graph traversal.

**CMP SCI 3710 Assembly Language Programming: 3 semester hours**
Prerequisite: CMP SCI 2700. Explores machine architecture concepts and principles through a study of assembly language programming. Topics covered include integer and floating point arithmetic, procedures, conditional processing, strings, macros, and interfaces to high level languages. Programming projects using a commercially available assembly language will be required.

**CMP SCI 4010 Advanced Web Development with Java: 3 semester hours**
Prerequisites: CMP SCI 2261 and CMP SCI 3010, or consent of instructor. Covers more advanced Java topics, along with related concepts and technologies for Web development. Topics may include database connectivity, multi threading, security, networking, MVC pattern, testing and source control for Java applications, and server-side topics such as servlets and web servers.

**CMP SCI 4012 Introduction to Enterprise Web Development: 3 semester hours**
Prerequisites: CMP SCI 4010. This course covers design and implementation issues for enterprise web development, and some popular advanced technologies. Topics include MVC and persistence frameworks, such as Spring and Hibernate. Other topics may include Java Web services, EJB, messaging standards such as JMS, and Java EE design patterns. Students will develop enterprise-level web application projects. Credit cannot be earned for both CMP SCI 4012 and CMP SCI 5012.

**CMP SCI 4020 Introduction to Android Apps: Android Fundamentals: 3 semester hours**
Prerequisites: CMP SCI 4010, or consent of the instructor. This course covers the fundamental programming principles, software architecture and user experience considerations underlying handheld software applications and their development environments. Includes in-depth, hands-on examples, implemented on the Android Platform, and discussion of security. Credit not granted for both CMP SCI 4020 and CMP SCI 5020.

**CMP SCI 4030 Introduction to Intelligent Web: 3 semester hours**
Prerequisites: CMP SCI 2261, CMP SCI 2750, CMP SCI 3010, and CMP SCI 3130. Covers the application of artificial intelligence and other modern techniques to help construct, navigate, and experience the Web. Topics may include retrieval models, classification, mining, association, topology, and indexing algorithms such as PageRank and HITS. Credit cannot be earned for both CMP SCI 4030 and CMP SCI 5030.

**CMP SCI 4140 Theory Of Computation: 3 semester hours**
Prerequisite: CMP SCI 3130. Provides an introduction to the theory of computation. Describes basic computational models, such as finite state machines, pushdown automata, Turing machines and grammars. Covers the concept of nondeterministic computation and the relationships between different computational models. Discusses decidability, reducibility, and classification of problems into complexity classes based on their time and space complexity, such as P, NP, and PSPACE.

**CMP SCI 4220 Introduction to iOS Programming and Apps: 3 semester hours**
Prerequisites: CMP SCI 2261, CMP SCI 2750, and CMP SCI 3010. This course covers Objective-C and uses it for building iOS apps. It also introduces Xcode, Interface Builder, basic architectural patterns for MVC such as action, delegation, and outlets. Additional topics may include online services, mapping, persistence with core data, and single and multiple views.

**CMP SCI 4222 iOS Apps: 3 semester hours**
Prerequisites: CMP SCI 4220 or consent of the instructor. This course focuses on building more sophisticated apps using Objective-C and the scripting language Swift. May include networking such as web services, Bluetooth and wifi connectivity, graphics and animation in 2-d and 3-d, autolayouts, OpenGL, advanced data sources such as plist and core data, source control and unit testing. May also discuss security topics. Credit not granted for both CMP SCI 4222 and CMP SCI 5222.

**CMP SCI 4250 Programming Languages: 3 semester hours**
Prerequisite: CMP SCI 2261 and CMP SCI 3010 or Graduate Standing. Studies the principles, approaches, and trade-offs in modern programming languages, including a comparative study of syntax, semantics, and pragmatics. Examines major programming paradigms: object-oriented, imperative, functional and logic.

**CMP SCI 4280 Program Translation: 3 semester hours**
Prerequisites: CMP SCI 2700, CMP SCI 2750, CMP SCI 3130, and CMP SCI 4250. Focuses on methods, techniques, and mechanisms used to create the abstraction from high level programming to machine level execution. This course also requires an individual, semester long project.

**CMP SCI 4300 Introduction To Artificial Intelligence: 3 semester hours**
Prerequisites: CMP SCI 2261, CMP SCI 2750 and CMP SCI 3130. Provides an introduction to artificial intelligence. The list of topics may include search, planning, knowledge-based reasoning, probabilistic inference, machine learning, natural language processing, and practical applications.

**CMP SCI 4340 Introduction to Machine Learning: 3 semester hours**
Prerequisites: CMP SCI 2261, CMP SCI 2750 and CMP SCI 3130. Provides an introduction to machine learning in the context of applications such as data mining, natural language processing, and adaptive computer systems. The course reviews several supervised, unsupervised, and reinforcement machine learning techniques such as naive Bayes networks, clustering, and decision trees. Selected concepts in computational learning theory may also be covered. Credit cannot be granted for both CMP SCI 4340 and CMP SCI 5340.

**CMP SCI 4410 Computer Graphics: 3 semester hours**
Prerequisites: CMP SCI 2750 and CMP SCI 3130. Covers the theoretical foundation and algorithms for computer graphics. Students learn the basics of graphics programming for modeling, rendering, and animation of 2D and 3D objects. Vector and raster graphics, and different display devices are also discussed. A brief discussion of special graphics hardware, such as GPU, may be presented.
**CMP SCI 4420 Introduction to Digital Image Processing: 3 semester hours**
Prerequisites: CMP SCI 2750 and CMP SCI 3130. Focuses on image analysis and visual perception. Students learn data structures and algorithms for image processing, region and texture analysis, image filtering, edge detection, contour following, and image enhancement in both spatial and frequency domain. Other topics may include color processing, coding for storage, retrieval, transmission, and image restoration. Credit cannot be granted for both CMP SCI 4420 and CMP SCI 5420.

**CMP SCI 4500 Introduction to the Software Profession: 3 semester hours**
Prerequisite: CMP SCI 2261, CMP SCI 2700, CMP SCI 2750, CMP SCI 3010, and CMP SCI 3130. Focuses on software development and on the skills required for success in the software profession. Topics related to software development may include software process, models and views, software architectures, documentation, and testing strategies. Topics related to the profession may include ethics, licensing, copyright, trademarks, and professional conduct. Individual and group projects, research, and presentations may be required in this capstone course.

**CMP SCI 4520 Introduction to Object-Oriented Analysis And Design: 3 semester hours**
Prerequisite: CMP SCI 2261, CMP SCI 3010, CMP SCI 3130. Covers object-oriented development, illustrated with a visual modeling language and following an agile process. Discusses elements of analysis, requirements, design, implementation, and deployment such as use cases, static and dynamic diagrams, patterns, and frameworks. This course includes a semester long project starting with requirements and culminating with deployment. Credit not granted for both CMP SCI 4520 and CMP SCI 5520.

**CMP SCI 4610 Database Management Systems: 3 semester hours**
Prerequisites: CMP SCI 2750 and MATH 3000. Focuses on database theory and applications, with emphasis on the relational model. Topics include database design, modeling, file systems, indexing, integrity constraints, relational algebra, normalization, transaction processing, and concurrency control. Students are exposed to emerging DBMS technologies and applications. Several programming projects will be required, using a popular SQL server.

**CMP SCI 4700 Computer Forensics: 3 semester hours**
Prerequisites: CMP SCI 2700, CMP SCI 2750, and CMP SCI 3010. This course explores topics and methodologies for examining digital evidence, along with some principles of the investigative process. Includes memory, file system, operating system, network, and mobile device forensics. Addresses both theory and hands-on aspects for conducting digital forensic examinations.

**CMP SCI 4710 Mobile And Ubiquitous Computing: 3 semester hours**
Prerequisites: CMP SCI 2261. This course provides an introduction to the rapidly developing field of ubiquitous computing while at the same time exploring more focused topics in the three main categories of this field, namely systems, experience, and sensors. Explores setting up the infrastructure, privacy issues, evaluation of field applications, internationalization, user interfaces, and geolocation analysis.

**CMP SCI 4730 Computer Networks and Communications: 3 semester hours**
Prerequisites: CMP SCI 2750 and MATH 1320. This course provides a broad overview of computer networks and communications. Covers the fundamental principles and protocols across the whole layering structure of the Internet protocol stack. A top-down approach covers multiple topics including network application layer, transport layer, network layer, link layer, and physical layer protocols. May also include a range of related technologies such as WWW, HTTP, FTP, DNS, SMTP, TCP, UDP, ICMP, IPv4, IPv6, OSPF, RIP, BGP, IEEE 802.11 (WiFi), cellular networks, LANs, Ethernet, CSMA/CD, CDMA, multimedia networking, network management, and security in Internet.

**CMP SCI 4750 Introduction to Cloud Computing: 3 semester hours**
Prerequisites: CMP SCI 2750. This course provides an introduction to development and deployment of applications in the cloud space. Touches on different aspects of cloud computing such as IaaS, PaaS, and SaaS. Includes significant discussion on legal and security aspects of clouds in the marketplace. May also include public, private, and hybrid clouds, and Internet of Things. Credit not granted for both CMP SCI 4750 and CMP SCI 5750.

**CMP SCI 4760 Operating Systems: 3 semester hours**
Prerequisites: CMP SCI 2750, CMP SCI 2700, and CMP SCI 3130. Covers the structure of a generic operating system, considering in detail the algorithms for interprocess communication, process scheduling, resource management, memory management, file systems, and device management. Presents examples from contemporary operating systems. This course also requires practical projects implemented within a modern operating system or simulator environment.

**CMP SCI 4780 Computer and Network Security: 3 semester hours**
Prerequisites: CMP SCI 2750. This course provides a broad overview of computer and network security technologies and concerns from multiple perspectives, such as cryptography, Public Key Infrastructures (PKI), hashes and message digests, computer viruses and malware, email security, TCP/IP security, IPSec, Secure Socket Layer (SSL), Transport Layer Security (TLS), Virtual Private Networks (VPN), Firewall, AAA (Authentication, Authorization, Accounting), wireless and mobile systems security, secure identifications (IDs), cloud security, privacy and integrity, network attacks, system monitoring, and Intrusion Detection System (IDS). Management and human factors related to security will also be discussed.

**CMP SCI 4782 Information Security: 3 semester hours**
Prerequisites: CMP SCI 4730 or CMP SCI 4780 or consent of instructor. This course covers topics related to maintaining security in an organizational infrastructure, including risk analysis of the environment, access level and control including multi-factor authentication, and detection capabilities to ensure adequate security monitoring. Additional topics may include network level protections, firewalls, intrusion detection/prevention systems, securing web and mobile applications, securing cloud implementations, and overall architectural considerations for system security. Credit not granted for both CMP SCI 4782 and CMP SCI 5782.

**CMP SCI 4880 Individual Studies: 1-3 semester hours**
Prerequisites: Consent of the instructor. This course allows a student to pursue individual studies under the supervision of a faculty member. It may include development of a software project. The course may be repeated for credit.

**CMP SCI 4890 Topics In Computer Science: 3 semester hours**
Prerequisites: Consent of the Instructor. Covers a special topic in computer science to be determined by recent developments in the field and the interests of the instructor. Course may be repeated for credit.
CMP SCI 5012 Enterprise Web Development: 3 semester hours
Prerequisite: CMP SCI 4010 or consent of instructor. Covers design and implementation issues for enterprise web development, and some popular advanced technologies. Topics include MVC and persistence frameworks, such as Spring and Hibernate. Other topics may include Java Web services, EJB, messaging standards such as JMS, and Java EE design patterns. Students will develop enterprise-level web application projects. Credit cannot be earned for both CMP SCI 4012 and CMP SCI 5012.

CMP SCI 5020 Android Apps: Android Fundamentals: 3 semester hours
Prerequisites: CMP SCI 4010 or consent of the instructor. Covers the fundamental programming principles, software architecture and user experience considerations underlying handheld software applications and their development environments. Involves in-depth, hands-on examples, implemented on the Android Platform, and discussion of security. Credit not granted for both CMP SCI 4020 and CMP SCI 5020.

CMP SCI 5030 Intelligent Web: 3 semester hours
Prerequisite: Consent of the instructor. Covers the application of artificial intelligence and other modern techniques to help construct, navigate, and experience the Web. Topics may include retrieval models, classification, mining, association, topology, and indexing algorithms such as PageRank and HITS. Topics are the same as CMP SCI 4030 but material is covered at a greater depth and additional projects are required. Credit cannot be earned for both CMP SCI 4030 and CMP SCI 5030.

CMP SCI 5130 Advanced Data Structures And Algorithms: 3 semester hours
Prerequisite: An elementary course in analysis of algorithms or consent of the instructor. This course covers analysis of time and space complexity of iterative and recursive algorithms along with performance bounds, design of data structures for efficient performance, sorting algorithms, probabilistic algorithms, divide and conquer strategies, various algorithms on graphs, and NP completeness.

CMP SCI 5222 Advanced iOS Apps: 3 semester hours
Prerequisites: CMP SCI 4220 or consent of the instructor. Focuses on building sophisticated apps using Objective-C and the scripting language Swift. Will cover recent developments in networking such as web services, Bluetooth and wifi connectivity, graphics and animation in 2-d and 3-d, autolayouts, OpenGL, advanced data sources such as plist and core data, source control and unit testing. May also discuss security topics. Credit not granted for both CMP SCI 4222 and CMP SCI 5222.

CMP SCI 5320 Introduction To Evolutionary Computation: 3 semester hours
Prerequisites: CMP SCI 4300 or consent of the instructor. This course introduces the concepts of nature-inspired problem solving population dynamics, Darwinian selection, and inheritance. It discusses problems applicable to evolutionary algorithms, overviews the existing models and instances, and analyzes specific instances such as genetic algorithms and genetic programming.

CMP SCI 5340 Machine Learning: 3 semester hours
Prerequisites: Consent of instructor. Provides an introduction to machine learning in the context of applications such as data mining, natural language processing and adaptive computer systems. Reviews several supervised, unsupervised, and reinforcement machine learning techniques such as naive Bayes networks, clustering and decision trees. Selected concepts in computational learning theory may also be covered. Topics are the same as CMP SCI 4340 but material is covered at a greater depth and additional projects are required. Credit cannot be granted for both CMP SCI 4340 and CMP SCI 5340.

CMP SCI 5420 Digital Image Processing: 3 semester hours
Prerequisites: Consent of instructor. Covers topics in image analysis and visual perception. Students learn data structures and algorithms for image processing, region and texture analysis, image filtering, edge detection, contour following, and image enhancement in both spatial and frequency domain. Other topics may include color processing, coding for storage, retrieval, transmission, and image restoration. Topics are the same as CMP SCI 4420 but material is covered at a greater depth and additional projects are required. Credit cannot be granted for both CMP SCI 4420 and CMP SCI 5420.

CMP SCI 5500 Software Engineering: 3 semester hours
Prerequisite: Consent of instructor. Introduces software engineering as a discipline, discusses stages of the software life cycle, compares development models such as waterfall, prototyping and incremental/iterative, covers requirements analysis, effort and cost estimation, compares structured and object-oriented analysis and design methods. Discusses verification/validation, quality assurance, software reliability, testing methods, maintenance, documentation, project management and team structure, metrics, and available tools.

CMP SCI 5520 Object Oriented Analysis And Design: 3 semester hours
Prerequisite: Consent of the instructor. Covers object-oriented development, illustrated with visual modeling language and following an agile process. Discusses elements of analysis, requirements, design, implementation, and deployment such as use cases, static and dynamic diagrams, patterns and frameworks. A semester long project, starting with requirements and culminating with deployment, is required. Topics are the same as CMP SCI 4520 but material is covered at a greater depth and additional projects are required. Credit not granted for both CMP SCI 4520 and CMP SCI 5520.

CMP SCI 5700 Computer Systems: 3 semester hours
Prerequisite: Background in computer organization or architecture or consent of the instructor. This course focuses on parallel computing architectures, including RISC, pipelining, vector processing, SIMD, MIMD, and array processing. It introduces different memory and I/O subsystems, hardware description languages, and it demonstrates performance enhancement using different architectures studied.

CMP SCI 5740 High Performance Computing: 3 semester hours
Prerequisite: Consent of the instructor. Introduces algorithms for multiprocessor and multi-core architectures. Students learn the models of modern parallel computation and techniques to take advantage of parallel architectures for distributed and shared memory multi-processor architectures.

CMP SCI 5750 Cloud Computing: 3 semester hours
Prerequisites: Graduate Standing. Provides an introduction to development and deployment of applications in the cloud space. Touches on different aspects of cloud computing such as IaaS, PaaS, and SaaS. Includes significant discussion on legal and security aspects of clouds in the marketplace. May also include public, private, and hybrid clouds, and Internet of Things. Credit not granted for both CMP SCI 4750 and CMP SCI 5750.
**CMP SCI 5782 Advanced Information Security: 3 semester hours**
Prerequisites: Consent of the instructor. The topics covered in this course are risk analysis to understand the security requirements of an environment; access controls to understand the level of controls needed for different practical situations, including multi-factor authentication; detection capabilities, to ensure adequate security monitoring for information systems; network level protections, with firewalls, intrusion detection/prevention systems; securing the web and mobile applications and cloud implementations; and overall security architecture to understand how various controls can provide the security-in-depth that is required in the current environment. Credit not granted for both CMP SCI 4782 and CMP SCI 5782.

**CMP SCI 5880 Computer Science Independent Project: 1-3 semester hours**
Prerequisites: Graduate standing and consent of instructor. This course offers the student an opportunity to work on an advisor-supervised project, individually or in a group. A student may repeat the course for up to 6 credit hours total, but at most 6 hours can be accumulated for CMP SCI 5880 and CMP SCI 6900.

**CMP SCI 5890 Topics In Computer Science: 1-3 semester hours**
Prerequisites: Graduate standing and consent of the instructor. This course offers various topics not offered on a regular basis. It may be taken more than once for credit with the consent of the department.

**CMP SCI 5900 Graduate Internship in Computer Science: 3 semester hours**
Prerequisites: Consent of Advisor. The internship provides for a student to attain field experience in an organization related to Computer Science. A student is employed off-campus for an assignment of at least 320 hours working on a project as directed by his/her supervisor in the host organization. The project should be approved by the student's academic advisor, or a designated faculty member, who will monitor the student's progress. The student is responsible for having the project supervisor at the company establish contact with the academic advisor to establish schedule and goals, and a procedure to evaluate the goals. The student will submit a written report to the advisor at the end of internship. The course cannot be repeated for credit. Students completing this course will be allowed only up to three hours of Independent Study (CMP SCI 5880). The internship course does not count towards any baccalaureate degree.

**MATH 0005 Intermediate Algebra: 3 semester hours**
Prerequisites: Consent of the instructor. The topics covered in this course are risk analysis to understand the security requirements of an environment; access controls to understand the level of controls needed for different practical situations, including multi-factor authentication; detection capabilities, to ensure adequate security monitoring for information systems; network level protections, with firewalls, intrusion detection/prevention systems; securing the web and mobile applications and cloud implementations; and overall security architecture to understand how various controls can provide the security-in-depth that is required in the current environment. Credit not granted for both CMP SCI 4782 and CMP SCI 5782.

**MATH 1020 Contemporary Mathematics: 3 semester hours**
Prerequisites: Consent of the instructor. The topics covered in this course are risk analysis to understand the security requirements of an environment; access controls to understand the level of controls needed for different practical situations, including multi-factor authentication; detection capabilities, to ensure adequate security monitoring for information systems; network level protections, with firewalls, intrusion detection/prevention systems; securing the web and mobile applications and cloud implementations; and overall security architecture to understand how various controls can provide the security-in-depth that is required in the current environment. Credit not granted for both CMP SCI 4782 and CMP SCI 5782.

**MATH 1021 Choice and Chance: 3 semester hours**
Same as PHIL 1021. Prerequisites: A satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. Preparatory material for college level mathematics courses. Covers systems of linear equations and inequalities, polynomials, rational expressions, exponents, quadratic equations, graphing linear and quadratic functions. This course carries no credit towards any baccalaureate degree.

**MATH 1025 Geometry in the Real World: 3 semester hours**
Prerequisites: Consent of the instructor. This course covers new developments in digital image processing, computer vision, and multimedia. Topics to be covered may include image databases, object tracking, and large-scale data visualization.

**MATH 6420 Topics In Image Processing And Multimedia: 3 semester hours**
Prerequisites: CMP SCI 5400, CMP SCI 5420 or consent of instructor. This course covers new developments in digital image processing, computer vision, and multimedia. Topics to be covered may include image databases, object tracking, and large-scale data visualization.

**MATH 6740 High Performance Computing: 3 semester hours**
Prerequisites: CMP SCI 5740, or Graduate standing and consent of instructor. Looks at the current state of the art in parallel and distributed computing, with emphasis on programming in such environments. Introduction to the state of the art in code optimization and grid computing environments.

**MATH 6900 Thesis: 1-6 semester hours**
Prerequisites: Completion of at least 12 graduate credits and approval of research topic by thesis advisor. This course is designed for those students intending to present a thesis as part of their M.S. program. At most 6 hours can be accumulated for CMP SCI 5880 and CMP SCI 6900.
**MATH 1030 College Algebra: 3 semester hours**
Prerequisites: A satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course, or approval of the department. Topics in algebra and probability, polynomial functions, the binomial theorem, logarithms, exponentials, and solutions to systems of equations.

**MATH 1035 Trigonometry: 2 semester hours**
Prerequisite: MATH 1030 or MATH 1040, or concurrent registration in either of these two courses, or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. A study of the trigonometric and inverse trigonometric functions with emphasis on trigonometric identities and equations.

**MATH 1040 College Algebra for Science and Engineering: 4 semester hours**
Prerequisites: A satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. Topics in this course include factoring, simplifying rational functions, functions and their graphs, solving linear and nonlinear equations, polynomial functions, inverse functions, the binomial theorem, logarithms, exponentials, solutions to systems of equations using matrices, solutions to nonlinear systems of equations, and sequences.

**MATH 1045 PreCalculus: 5 semester hours**
Prerequisite: A satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. Topics in this course include factoring, simplifying rational functions, functions and their graphs, solving linear and nonlinear equations, polynomial functions, inverse functions, the binomial theorem, logarithms, exponentials, solutions to systems of equations using matrices, solutions to nonlinear systems of equations, and sequences. Students will also study trigonometric and inverse trigonometric functions with emphasis on trigonometric identities and equations.

**MATH 1100 Basic Calculus: 3 semester hours**
Prerequisite: MATH 1030 or MATH 1040 or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. Introduction to plane analytic geometry and basic differential and integral calculus with applications to various areas. No credit for Mathematics majors. Credit not granted for both MATH 1800 and MATH 1100.

**MATH 1102 Finite Mathematics: 3 semester hours**
Prerequisites: MATH 1030 or MATH 1040 or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. Introduction to plane analytic geometry and basic differential and integral calculus with applications to various areas. No credit for Mathematics majors. Credit not granted for both MATH 1800 and MATH 1100.

**MATH 1105 Basic Probability And Statistics: 3 semester hours**
Prerequisites: MATH 1030 or MATH 1040 or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. An introduction to probability and statistics. Topics include the concept of probability and its properties, descriptive statistics, discrete and continuous random variables, expected value, distribution functions, the central limit theorem, random sampling and sampling distributions. Credit not granted for more than one of MATH 1310, MATH 1320, and MATH 1105.

**MATH 1150 Structure Of Mathematical Systems I: 3 semester hours**
Prerequisites: 45 hours of college credit and a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course OR successful completion of MATH 1030 no more than 2 years prior to enrollment in this course. A study of sets, relations, functions, whole numbers; the integers and their properties, and the rational and real number systems.

**MATH 1310 Elementary Statistical Methods: 3 semester hours**
Prerequisite: MATH 1030 or MATH 1040 or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. An introduction to the basic tools and elementary methods of statistics, such as testing of hypotheses, analysis of variance, method of least squares, and time series. A student may not receive credit for more than one of MATH 1310, MATH 1320, and MATH 1105.

**MATH 1320 Applied Statistics I: 3 semester hours**
Prerequisites: MATH 1030 or MATH 1040 or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. An introduction to plane analytic geometry and calculi.

**MATH 1800 Analytic Geometry And Calculus I: 5 semester hours**
Prerequisites: MATH 1030 and MATH 1105, or MATH 1040 and MATH 1035, or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course, or approval of the department. This course provides an introduction to differential and integral calculus. Topics include limits, derivatives, related rates, Newton's method, the Mean-Value Theorem, Max-Min problems, the integral, the Fundamental Theorem of Integral Calculus, areas, volumes, and average values.

**MATH 1900 Analytic Geometry And Calculus II: 5 semester hours**
Prerequisite: MATH 1800. Topics include conic sections, rotation of axes, polar coordinates, exponential and logarithmic functions, inverse (trigonometric) functions, integration techniques, applications of the integral (including mass, moments, arc length, and hydrostatic pressure), parametric equations, infinite series, power and Taylor series.

**MATH 2000 Analytic Geometry And Calculus III: 5 semester hours**
Prerequisite: MATH 1900. Topics include vectors, cylindrical and spherical coordinates, vector-valued functions, arc length and curvature, functions of several variables, partial and directional derivatives, gradients, extrema, Lagrange multipliers, multiple integrals, change of variables, surface area, vector fields, Stokes' Theorem.

**MATH 2020 Introduction To Differential Equations: 3 semester hours**
Prerequisite: MATH 2000. Topics will be chosen from: linear differential equations, equations with constant coefficients, laplace transforms, power series solutions, systems of ordinary differential equations.

**MATH 2450 Elementary Linear Algebra: 3 semester hours**
Prerequisite: MATH 1100 or MATH 1900. An introduction to linear algebra. Topics will include complex numbers, geometric vectors in two and three dimensions and their linear transformations, the algebra of matrices, determinants, solutions of systems of equations, eigenvalues and eigenvectors.
MATH 2510 Structure Of Mathematical Systems II: 3 semester hours
Prerequisite: MATH 1150. An introduction to probability and statistics. An intuitive study of elementary geometry. Introduction to the deductive theory of geometry and to coordinate geometry.

MATH 3000 Discrete Structures: 3 semester hours
Prerequisites: MATH 1900 or MATH 1100, and CMP SCI 1250 or equivalent. Treats fundamental ideas in discrete structures and serves as a foundation for subsequent courses in both Mathematics and Computer Science. Provides an introduction to techniques of mathematical reasoning with examples derived from computer science. Topics include logic, set algebra, equivalence relations and partitions, functions, mathematical induction, elementary number theory, cardinality, recurrence relations, basic combinatorial methods, trees and graphs. Credit not granted for more than one of CMP SCI 3000, and MATH 3000.

MATH 3100 Problem Solving In Mathematics: 1 semester hour
Prerequisite: MATH 2000. Course will train students to solve and write solutions to challenging mathematical problems, like those found in competitive exams like the Putnam Exam.

MATH 3520 Structure Of Mathematical Systems III: 3 semester hours
Prerequisite: MATH 2510 Together with MATH 1150 and MATH 2510, this course teaches the mathematics necessary for middle school mathematics certification. Topics from MATH 1150 and MATH 2510 are continued. Other topics include geometric constructions, similarity, coordinate geometry, normal distribution, combinatorics, and trigonometry.

MATH 4010 Financial Mathematics I: 3 semester hours
Prerequisites: MATH 1900 or MATH 1100, and MATH 1320 or LOG OM 3300 (or equivalents). An introduction to the theory of interest, annuities (certain), annuities with differing pay periods, amortization schedules and sinking funds.

MATH 4020 Financial Mathematics II: 3 semester hours
Prerequisites: MATH 4010. Premium-discount formula for bonds, bond amortization, term structure of interest rates and pricing theory for options.

MATH 4030 Applied Mathematics I: 3 semester hours
Prerequisite: MATH 2020 and MATH 2450. Topics chosen from Fourier series, special functions, partial differential equations, and boundary value problems.

MATH 4040 Applied Differential Equations: 3 semester hours
Prerequisites: MATH 2020 and MATH 2450. The study of ordinary differential equations and partial differential equations is continued with applications in such areas as physics, engineering and biology.

MATH 4100 Real Analysis I: 3 semester hours
Prerequisites: MATH 2000 and MATH 3000. Introduction to real analysis in one variable. Topics include the real number system, limits, continuity, differentiability, and sequences and series of functions.

MATH 4160 Complex Analysis I: 3 semester hours
Prerequisites: MATH 2020 or both MATH 3000 and MATH 2000. Complex numbers and their geometrical representation, point sets, analytic functions of a complex variable, complex integration, Taylor and Laurent series, residue theorem, conformal mapping.

MATH 4200 Mathematical Statistics I: 3 semester hours
Prerequisites: MATH 4200. Continuation of MATH 4200. Sampling distributions, estimation theory, properties of estimators, hypothesis testing, Neyman-Pearson Theorem, likelihood ratio tests, introduction of analysis of variance and linear models. Basics of some nonparametric procedures.

MATH 4230 Numerical Analysis I: 3 semester hours
Prerequisites: MATH 2020, MATH 2450, and the ability to program in an upper-level language. Solutions of equations, interpolation and approximation numerical differentiation and integration, and numerical solutions of initial value problems in ordinary differential equations. Selected algorithms will be programmed for solution on computers.

MATH 4260 Introduction To Stochastic Processes: 3 semester hours
Prerequisites: MATH 4200. Basic theory and applications of stochastic processes. Markov chains, recurrent and transient states, stationary distributions, ergodic theorem, renewal processes, discrete martigales and stationary processes.

MATH 4350 Theory Of Numbers: 3 semester hours
Prerequisites: MATH 3000 and MATH 2000, or consent of instructor. Properties of integers, multiplicative functions, congruences, primitive roots, and quadratic residues.

MATH 4390 Topics In Probability And Statistics: 3 semester hours
Prerequisites: Consent of Instructor. A seminar on special topics in probability and statistics to be determined by the interests of the instructor. May be repeated for credit provided different topics are studied.

MATH 4400 Introduction To Abstract Algebra I: 3 semester hours
Prerequisites: MATH 3000 and MATH 2000, or consent of the department. Introduction to groups, rings, and fields, with emphasis on groups and rings.

MATH 4450 Linear Algebra: 3 semester hours
Prerequisites: MATH 3000, MATH 2000 and MATH 2450. Topics selected from vector spaces, bases, linear transformations, matrices, canonical forms, eigenvalues, hermitian and unitary matrices, inner product spaces, and quadratic forms.

MATH 4500 Special Readings: 1-10 semester hours
Prerequisites: MATH 3000, MATH 2000 and consent of instructor.

MATH 4550 Combinatorics: 3 semester hours
Prerequisites: MATH 3000 and MATH 2000. Advanced counting methods are introduced, including the use of generating functions for the solution of recurrences and difference equations. Additional topics may include: graphs and trees, combinatorial designs, combinatorial games, error-correcting codes, and finite-state machines.

MATH 4660 Foundations Of Geometry: 3 semester hours
Prerequisites: MATH 3000 and MATH 2000, or consent of the department. A development of portions of Euclidean geometry from a selected set of axioms, including a discussion of consistency, independence, categoricity, and completeness of the axioms.

MATH 4670 Introduction To Non-Euclidean Geometry: 3 semester hours
Prerequisites: MATH 3000 and MATH 2000, or consent of the department. A summary of the history of the non-Euclidean geometries and a study of hyperbolic plane geometry.

MATH 4800 Introduction To Topology: 3 semester hours
Prerequisites: MATH 3000 and MATH 2000, or consent of the department. A study of topological spaces, including the concepts of limit, continuity, connectedness, compactness, etc. Special emphasis placed on, and examples taken from, the space of real numbers.
MATH 4890 Topics In Mathematics: 3 semester hours  
Prerequisite: Consent of Instructor.

MATH 5060 Computational Harmonic Analysis: 3 semester hours  
Prerequisites: MATH 4030, MATH 4100 and MATH 4450. The course covers the basics of Fourier analysis and wavelet analysis. Topics include Fourier transforms and series, discrete Fourier transform, discrete cosine transform and their fast computational schemes, fast wavelet transform, and the lifting scheme. Additional topics include industrial standards for image compression and several aspects of signal processing.

MATH 5100 Real Analysis II: 3 semester hours  
Prerequisites: MATH 4100. Introduction to measure and integration. Topics include the Riemann-Stieltjes integral, Lebesgue measure, measurable functions, the Lebesgue integral, Radon-Nikodym and Fubini theorems and the basics of Lp-spaces.

MATH 5110 Differentiable Manifolds: 3 semester hours  
Prerequisites: MATH 4100, MATH 4450, and MATH 4800. An introduction to smooth manifolds and maps. Topics will include the Implicit Function Theorem, Sard's Theorem, transversality, intersection and degree theory, differential forms and integration on manifolds.

MATH 5140 Set Theory And Metric Spaces: 3 semester hours  
Prerequisites: MATH 4100 or consent of instructor. Naive set theory, cardinal arithmetic, ordinal numbers, the axiom of choice and equivalents, metric spaces, convergence, continuity, compactness, contraction principals and applications. Construction of completions and examples like real numbers and p-adic numbers. Other topics could include the Stone-Weierstrass theorem and metrizability theorems.

MATH 5160 Complex Analysis II: 3 semester hours  
Prerequisites: MATH 4160 and either MATH 4100 or MATH 4800. A second course in complex analysis, emphasizing the theory of analytic functions, and including various topics like the Riemann mapping theorem, normal families, analytic continuation, representations of analytic functions, and elliptic functions.

MATH 5320 Applied Statistics: 3 semester hours  
Prerequisites: MATH 4210 or consent of instructor. The course studies classical and recently developed statistical procedures selected from areas including analysis of variance, multivariate analysis, nonparametric or semi-parametric methods and generalized linear models. Emphasis is on application of procedures, including the rationale underlying choice of procedures.

MATH 5500 Directed Readings: 1-6 semester hours  
Prerequisite: Consent of instructor. Independent readings at an advanced level.

MATH 5550 Topics In Advanced Math For The Teacher: 3 semester hours  
Prerequisite: Consent of Instructor. This course will look at various topics in Algebra, Analysis, and Geometry that will deepen a teacher's understanding of the Mathematics of the precollegiate curriculum. It can be taken more than once for credit.

MATH 5600 Topics In Computation: 3 semester hours  
Prerequisite: consent of instructor. The course will cover various advanced topics in computation, and can be taken more than once for credit. Examples of such topics are: computer graphics, computer architecture, theories of language, analysis of operating systems, numerical geometry and computer aided design, etc.

MATH 5710 Topics In Analysis: 3 semester hours  
Prerequisites: MATH 5100 or consent of instructor. Topics selected from the areas of Fourier analysis, harmonic analysis, functional analysis, special functions, generalized functions, and partial differential equations. May be taken more than once for credit with consent of department.

MATH 5820 Topics In Algebra: 3 semester hours  
Prerequisite: Consent of instructor. Topics selected from the theory of groups, rings, fields, algebras and other algebraic systems. May be taken more than once for credit with consent of department.

MATH 6900 Masters Thesis: 1-6 semester hours  
Prerequisite: Consent of instructor. Thesis work under the supervision of a faculty member. The course is designed for those students intending to present a thesis as part of their M.A. program. Students who do not write a thesis cannot apply MATH 6900 to a degree.

MATH 7990 Ph.D. Dissertation Research: 1-9 semester hours  
Prerequisites: Completion of Comprehensive. May be taken for no more than nine hours.