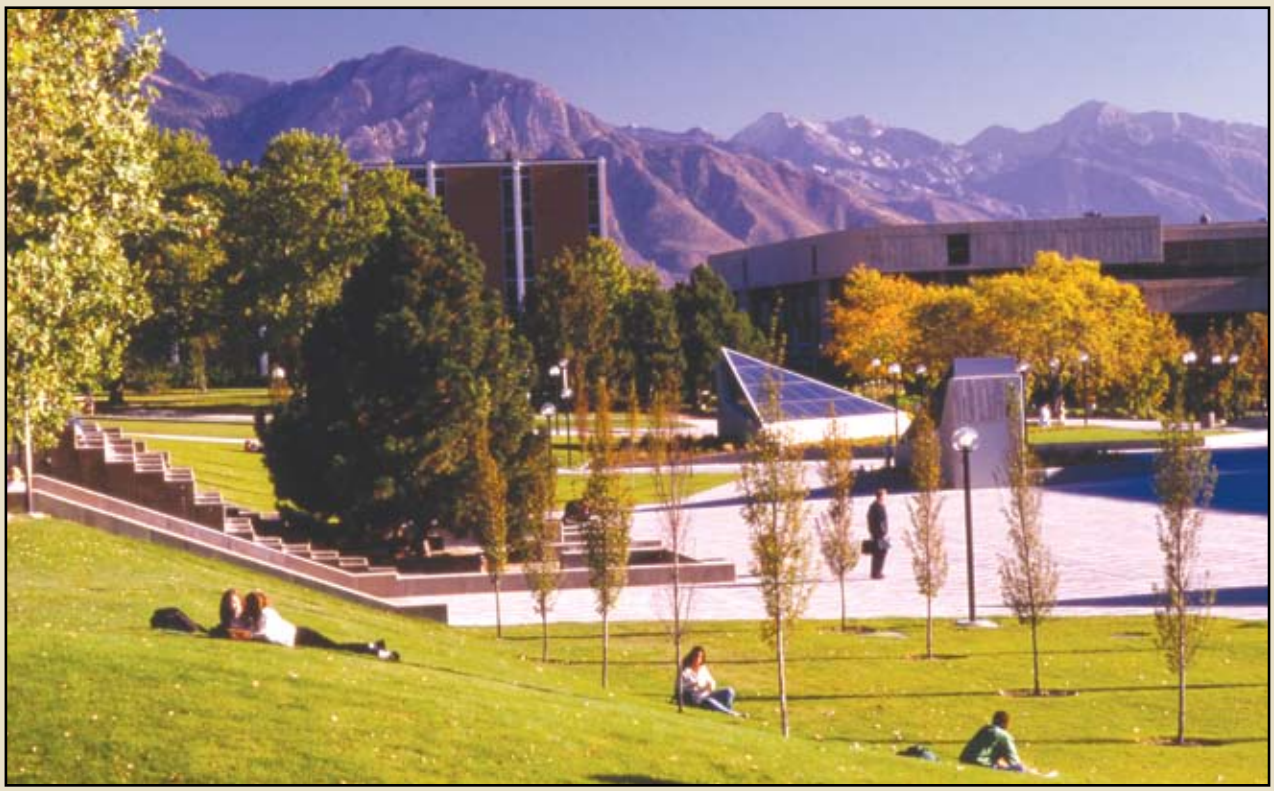
School of Computing

Graduate Student Handbook
2009-2010



School of Computing
THE UNIVERSITY OF UTAH

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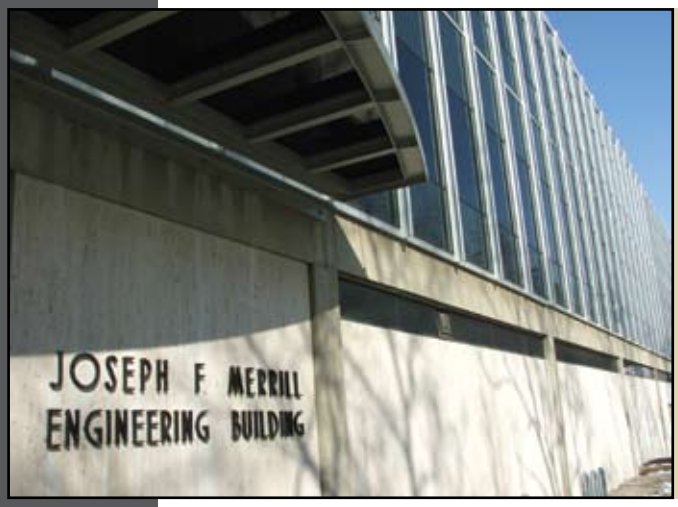
Welcome to the School of Computing



"Almost every influential person in the modern computer-graphics community either passed through the University of Utah or came into contact with it in some way."

-The Algorithmic Image:
Graphic Visions of the Computer Age
by Robert Rivlin

The School of Computing was originally founded as the Computer Science Department at the University of Utah in 1965 by three electrical engineering faculty members (In 2000, the department officially became the School of Computing). In 1985, the department reached 10 full-time faculty members. By 1996, it had doubled to 20. Today the School of Computing boasts 35 regular faculty members, two research faculty, and nine adjunct faculty, with more than 300 CS undergraduate students, 110 CE undergrads, 65 enrolled in the M.S. program and 100 enrolled in the CS Ph.D. program.

Our Research Areas Include:

- Computer Graphics and Visualization
- Computer Systems
- Information Management
- Natural Language Processing and Machine Learning
- Program Analysis, Algorithms and Formal Methods
- Robotics
- Scientific Computing
- Computer Architecture

The School of Computing at the University of Utah has a long history of distinguished faculty and alumni who have made substantial contributions to research and industry. SoC Ph.D. graduate John Warnock (1969) developed the Warnock recursive subdivision algorithm for hidden surface elimination, and later founded Adobe Systems, which developed the Postscript language for desktop publishing. Alan Ashton, 1970 Ph.D. graduate went on to teach at Brigham Young University and founded WordPerfect. Computer animation pioneer Ed Catmull, received both his B.S. and Ph.D. degrees in computer science from the University of Utah. Today he is the co-founder and president of Walt Disney and Pixar Animation Studios. He received a technical Academy Award in 1996 from the Academy of Motion Picture Arts and Sciences for "pioneering inventions in Digital Image Compositing".

Today's School of Computing faculty and students continue to carry the tradition of innovative research and technological advancements at the University of Utah.

Table of Contents

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Administration

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Computer graphics and animation

Professor & Dean, College of Engineering

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Computer vision, visualization, and image processing

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Front Desk

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Master's Degree Guidelines

There are four graduate degree programs within in the School of Computing (SoC) at the University of Utah:

- MS in Computer Science
- MS in Computing
- PhD in Computer Science
- PhD in Computing

A Computing degree is earned within a particular track. Each graduate student may enroll in one of those degree programs. Transfers between degree programs will be considered between semesters and will occur only once per academic year.

To remain in good standing, a student has to reach certain due progress milestones set by the SoC. For PhD students, a form specifying these milestones, as well as other necessary forms for graduate students, is posted on the Graduate Studies Committee website.

Independent study courses (CS 6950 and CS 7950) cannot be included in the Program of Study for the Ph.D. degree. Students may place out of this requirement by substituting or transferring courses from other institutions at the discretion of the TCF Chair.

SoC Graduate Degrees

Master's Degrees:

Master's in Computer Science

Non-Thesis Master's in Computer Science

Master's in Computing
Tracks:
- Computer Engineering
- Information Technology
- Graphics and Visualization
- Robotics
- Data Management and Analysis

Ph.D. Degrees:

Ph.D. in Computer Science

Ph.D. in Computing
Tracks:
- Computer Engineering
- Graphics and Visualization
- Robotics
- Scientific Computing
- Data Management and Analysis

The Program of Study form should be filed with the School of Computing in the second semester of study and with the Graduate School prior to taking the qualifying examination. The Program of Study form must be submitted to the Graduate Records Office no later than the last day of the semester proceeding the semester of graduation.

REGISTRATION REQUIREMENTS

Full-time graduate students in the School of Computing are ordinarily requested to register for 12 hours for TAs and 11 hours for RAs, which includes regular courses, seminars,

and research credits as appropriate. This is especially the case for students being supported via research or teaching assistantships. Students who are not being supported by the school are required to take nine hours to be classified as full- time.

Graduate School policy dictates that a graduate student who receives a full tuition waiver during any semester in which he or she holds an assistantship, fellowship or traineeship is required to register for at least nine semester hours, including thesis research and seminars.Students must be registered for at least three hours per semester, exclusive of summer semester, to remain in a graduate degree program. Students who do not maintain continuous registration and who have not been granted a leave of absence by the Graduate School are subject to being discharged from the degree program.

Students doing theses or dissertations must be registered for at least three semester hours during the semester of the student's thesis defense. Once a student has passed the thesis defense, the student does not have to register the next term if within the 90-day period to turn in the final thesis.

COURSE REQUIREMENTS

All degree programs have certain course requirements. However, these represent a necessary, rather than sufficient, set of courses for graduation. To graduate, this coursework must appear on a student's approved program of study, a customized course plan developed by the student in conjunction with their committee.

Courses that count toward graduation must be on the program of study. The following restrictions apply to these courses:

- CS courses must have a course number of 6000 or above (CS 5470: Compiler Principles and Techniques will also be allowed)
- Non-CS courses must have a course number of 5000 or above
- A grade of B- or better
- The GPA for all required courses must be at least 3.0

A student may register for CS 6020 if that student writes and publishes a peer-reviewed article based on research performed in the University of Utah School of Computing. The contribution of the student to the article should be equivalent to that conferred by first authorship. The paper should be published in a respectable outlet. It is the responsibility of the student's advisor to determine whether the student has made such a contribution, and whether the outlet is of sufficient quality. This paper must be accepted for publication prior to the end of the second year of study.

Master's Degree Guidelines

COURSE WAIVERS

A student may obtain a waiver for any of the required courses by demonstrating prior knowledge (e.g., completion of a similar course taken at another University). This waiver is obtained by petitioning the DGS. The waiver procedure should be initiated by first contacting the Graduate Coordinator. Waiving a required course does not reduce the 30 graduate credit hour requirement.

M.S. SUPERVISORY COMMITTEE

The M.S. Supervisory Committee consists of three members. At least two members must be SoC faculty. Any SoC regular faculty member may serve as a supervisory committee chair. Research or adjunct faculty may chair supervisory committees if accorded that privilege by the regular faculty. All official decisions of the committee are decided by majority vote.

M.S. COMPREHENSIVE EXAM

The M.S. comprehensive exam will be administered by the student's supervisory committee and can be coupled with a project or thesis proposal defense, and/or meeting a specified level of performance on a set of classes.

For students not doing a project or thesis, the comprehensive exam will typically be passed by meeting the grade requirements in required courses, but this can be modified at the discretion of the student's committee.

M.S. TRANSFER CREDIT

A student may not count more than nine semester hours of non-matriculated graduate work toward any graduate degree unless the student's registration for more than nine semester hours is specifically approved in advance by the SoC Director and the Dean of the Graduate School.

Graduate courses taken as an undergraduate at the University of Utah cannot be counted towards a degree program unless a petition for graduate credit was filed with the University's Registrar at the time the course was taken.

Students who have done graduate study at other institutions may transfer up to 6 semester hours to the University of Utah. The courses must be bona fide graduate level class

Master's Degree Guidelines

work (e.g., independent study is excluded), with grade B- or better. Students must be able to show that the course work was not used toward any other degree.

Approval of each course is granted by the student's supervisory committee and the DGS. Course appropriateness is determined by consideration of course content and the student's declared research area. Approved courses are certified by a transfer credit form. Approval of a course taken elsewhere for transfer credit does not imply fulfillment of any specific required course.

M.S. THESES AND PH.D DISSERTATIONS

The supervisory committee must give preliminary approval of the thesis or dissertation prior to the defense. The defense can be scheduled after this approval. To schedule the defense, contact the Graduate Coordinator. Students are strongly encouraged to schedule the defense during a regular colloquium slot.

The student must provide one copy of the thesis or dissertation to the chair of the supervisory committee at least three weeks before the defense, and one copy to each of the other committee members at least two weeks prior to the defense. A complete draft of the thesis or dissertation must be delivered to the Graduate Coordinator one week prior to the announced time of defense. This copy will be made available for public access. Students are encouraged to place an additional copy on the School of Computing web pages at least one week prior to the announced time of defense.

After successfully defending the thesis or dissertation, the student must obtain approval from the Final Reader (typically the supervisory committee chair), School Director, and Dean of the Graduate School. A draft of the final thesis or dissertation must then be presented to the Thesis Editor. Successful completion of the defense must be reported to the Graduate School at least four weeks before the last day of examinations in the final semester.

Students should also read the document regarding copyright notices provided by the School and declare their intentions regarding granting the School the right to photocopy the thesis or dissertation before notifying the Graduate Coordinator of completion of the defense.

Master's Degree Guidelines

The student has one month after the defense to make any revisions prior to submitting the thesis or dissertation to the Graduate School Thesis Editor. There will be at most two additional months to complete any changes required by the Thesis Editor before final acceptance. If either of these deadlines are not met, the candidate must redo the oral defense. The final thesis or dissertation must be filed one week before the end of the semester of graduation.

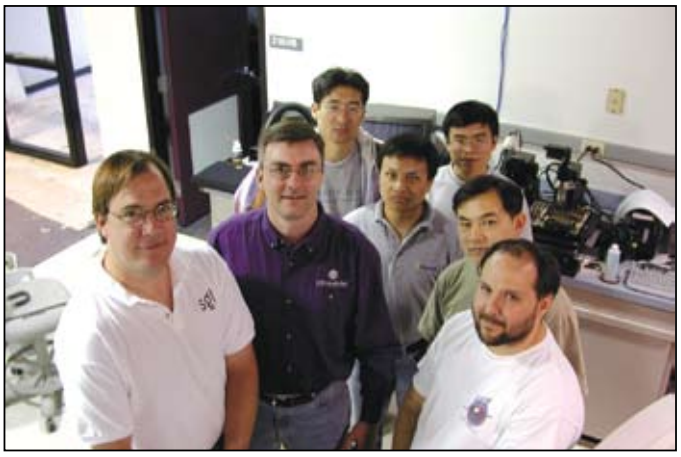
Students are expected to offer each committee member a bound copy of the thesis or dissertation once it is completed. Detailed policies and procedures concerning the thesis or dissertation are contained in "A Handbook for Theses and Dissertations" published by the Graduate School.

RESIDENCY

One year of study must be spent in full-time residency at the University (i.e., the student must enroll for a minimum of nine hours per semester for two consecutive semesters, summer optionally excluded). After the residency requirement is fulfilled, registration for three semester hours of CS 7970 (Ph.D. Dissertation Research) is considered a full load. At least 24 semester hours must be in resident study at the University of Utah.

LEAVE OF ABSENCE

If a student does not plan to take classes during a Fall or Spring semester, a leave of absence must be requested. Contact the Graduate Coordinator for the proper form.



MONITORING OF PROGRESS

Annual meetings and reports: Each year the student will prepare a one-page summary of their progress and submit it to the advisory committee in prepara-

Master's Degree Guidelines

GRADUATE STUDENT PROGRESS GUIDELINES FOR THE M.S. PROGRAM

Milestone	Good Progress	Acceptable Progress	Comments
Choose advisor	1 Semester	2 Semesters	
Full committee formed	2 Semesters	3 Semesters	
Program of study	2 Semesters	3 Semesters	
Complete required courses	3 Semesters	3 Semesters	Program requirement: 3 semesters
Defend proposal	3 Semesters	4 Semesters	U. requirement: 1 semester before defense
Thesis defense	4 Semesters	5 Semesters	
Final document			U. requirement: Within 3 months of defense

tion for a meeting that includes the student and advisory committee. The advisory committee will meet with the student and hear a presentation from the student and engage the student in a discussion about their progress in the program. A "meeting" in this context is some form of interactive communication between the student and the committee. The important aspect of this meeting is that the student and the committee be able to ask questions of one another and respond to those questions. In this document advisory committee refers to either the initial committee or full committee, depending on which committee is active during that particular part of the program.

The advisor will prepare a short report (approved by the advisory committee), which includes a checklist of milestones (using a form provided by the School). This report will

Master's Degree Guidelines

comment on any milestone that is not met within the time frame denoted as "good." In the event that students have unmet milestones that have passed the "acceptable" time frame (as indicated in the guidelines), the advisory committee can either request an exception to keep the student in good standing (and justify the exception) or recommend that the student not be considered in good standing.

The advisory committee will also give an overall evaluation of the student's progress as acceptable, unacceptable, or borderline and make recommendations of what (if any) actions should be taken by the student and the department.

Actions by the DGS and the School: In the event that a student is found not to be in good standing (a decision made by the DGS based on reports from the advisory committee) one or more actions may be taken. For example, the School may assign the DGS to counsel the student, deny opportunities to serve as departmentally funded TA, discontinue tuition waiver benets, or remove the student from the program. In the event that a faculty member fails to meet with advisory committees and report on their students, the DGS may elect to disallow this faculty to advise new students.

DEFENSE

Within three months of the dissertation defense, the student must receive final reading approval from the dissertation committee and the thesis editor. Failure to do so will result in probationary status and will require that the student re-defend the dissertation.

Master's and Ph.D. Defense

Action	Date	Recommendations
Thesis or dissertation proposal presented and passed	Prior to defense date	Committee guidelines
Possible defense date selected by committee	4 weeks prior to defense	Committee guidelines
Draft of dissertation or thesis sent to chair	4 weeks prior to defense	Committee guidelines
Draft to committee	3 weeks prior to defense	Committee guidelines
Message requesting approval of defense sent to committee by Graduate Coordinator	2 weeks prior to defense	School guidelines
Oral question and answer period after oral presentation	Day of defense	School guidelines
Document to Graduate Coordinator	10 days prior to defense	School guidelines
Abstract to Graduate Coordinator	10 days prior to defense	School guidelines
Posted on Web	10 days prior to defense	School guidelines
Meeting of committee to discuss issues and make recommendations	Day of defense	School guidelines
Signed final oral presentation document to Graduate Coordinator	Within days of defense	School guidelines
Thesis editor approval	3 months post defense	School guidelines

M.S. in Computer Science

The SoC offers two M.S. degrees, one in computer science, and one in computing. There is currently a robotics track, graphics and visualization track, information technology track, computer engineering track, and data management and analysis track available in computing. These degrees require 30 semester hours of graduate coursework, but differ in what courses a student must take.

At most, six semester hours can be courses outside of computer science. Seminars may not be counted.

COURSE REQUIREMENTS: M.S. IN COMPUTER SCIENCE

Students should select one course from each of the three categores. Three of these courses are required for students in both the thesis and non-thesis tracks.

CATEGORY #1	
CS 6100	Foundations of Computer Science
CS 6150	Algorithms
CATEGORY #2	
CS 6460	Operating Systems *
CS 6480	Computer Networks
CS 7460	Advanced Operating Systems
CATEGORY #3	
CS 6810	Advanced Computer Architecture *
CS 6710	Digital VLSI Design
CS 6720	Advanced Integrated Circuit Design
CS 6740	CAD of Digital Circuits
CS 6770	Advanced Digital VLSI Systems Design
CS 6830	VLSI Architecture
CS 7820	Parallel Computer Architecture

* Suggested course

M.S. in Computer Science

Students not doing a thesis must also take at least two courses from the following six choices:	
CS 5470	Compiler Principles and Techniques
CS 6210	Advanced Scientific Computing
CS 6300	Artificial Intelligence
CS 6480	Computer Networks
CS 6530	Database Systems
CS 7520	Programming Languages and Semantics

The following may also be used to fulfill this requirement:	
CS 6220	Advanced Scientific Computing II
CS 6350	Machine Learning
CS 6470	Advanced Topics in Compilation
CS 6510	Functional Programming
CS 6785	Advanced Embedded Systems
CS 7120	Information Based Complexity
CS 7460	Advanced Operating Systems
CS 7820	Parallel Computer Architecture

For students completing a thesis: at least one non-required CS course must be taken excluding independent study, seminars, or thesis research credit; independent study (CS 6950 and CS 7950) can be included in the required 30 semester hours only when the project is self-contained and independent of thesis research.

For students not completing a thesis, at most three of the required 30 semester hours can be independent study (CS 6950 and CS 7950).

M.S. in Computing: Robotics

COURSE REQUIREMENTS: M.S. IN COMPUTING, ROBOTICS TRACK The following three courses are required:	
CS 6310 / ME 6220	Introduction to Robotics
ME 6960	Introduction to Robot Control
CS 6370	Geometric Computation for Motion Planning
One course from each of these three areas are required:	
PERCEPTION	
CS 6320	Computer Vision
CS 7640	Image Processing for Graphics and Vision
COGNITION	
CS 6300	Artificial Intelligence
CS 6350	Machine Learning
CS 6330	Multiagent Systems
ACTION	
ME 5960/ 6960	Advanced Mechatronics
CS 6360	Virtual Reality
CS 7200	Nonlinear Controls
CS 7310/ ME 7230	Advanced Manipulation and Locomotion
CS 7370	System Indentification for Robotics
Two additional 6000-level courses are required (excluding independent study, seminars, or thesis research credit).	

M.S. in Computing: Information Technology

COURSE REQUIREMENTS: M.S. IN COMPUTING, IT Three courses from the following options are required:	
CS 6530	Database Systems
CS 6150	Advanced Algorithms
IS 6410	Systems Analysis and Design
IS 6480	Data Warehousing Design and Implementation
Students must choose three courses (9 credits) from the following list:	
CS 7965	Advanced Database Systems
CS 7960	Web Mining
CS 6350	Machine Learning
CS 6340	Natural Language Processing
CS 6964	Applications of Natural Language Processing
CS 6540	Human/ Computer Interaction
IS 6420	Database II
IS 6481	Management of Data Driven Products
IS 6482	Intro. to Data Mining
IS 6450	Telecom and Security
IS 6470	E-Business
IS 6491	Advanced Data Mining
Additional 6000-level courses may be required to reach a 30-credit minimum (excluding independent study, seminars, or thesis research credit).	

A student may pursue an M.S. with a (1) course-only option or (2) a project option. The minimum number of credits for either option is 30 graduate level classes (this includes 5000 or 6000 level courses as designated by departments). For the project option, students must take at least 3 and up to 6 credits of MS project research. Total of MS project and independent study should add up to no more than 6 credits.

M.S. in Computing: Graphics & Visualization

A student may pursue an M.S. with a (1) course-only option or (2) a project option. The minimum number of credits for either option is 30 graduate level classes (this includes 5000 or 6000 level courses as designated by departments). For the project option, students must take at least 3 and up to 6 credits of MS project research. Total of MS project and independent study should add up to no more than 6 credits.

COURSE REQUIREMENTS: M.S. IN COMPUTING, GRAPHICS AND VISUALIZATION TRACK (COURSE ONLY OPTION) Required courses:	
CS 6610	Advanced Computer Graphics I
CS 6630	Scientific Visualization
CS 6670	Computer Aided Geometric Design
CS 6640	Image Processing
Three courses from the following list are required:	
CS 6620	Advanced Computer Graphics II
CS 6650	Image Systhesis
CS 6360	Virtual Reality
CS 6320	Computer Vision
CS 6540	Human/ Computer Interaction
CS 6960	Computational Geometry
CS 6961	Fundamentals for Visual Computing
Elective courses (to equal 30 total credit hours):	
Graduate level CS courses and independent study (a maximum of three hours of independent study is allowed). Seminars cannot be counted.	
With approval of the supervisory committee, a student may take two elective courses at the graduate level or higher from other departments, excluding independent study, seminars, research credit.	
Thesis research hours are not counted toward the degree in the course-only option.	

M.S. in Computing: Graphics & Visualization

COURSE REQUIREMENTS: M.S. IN COMPUTING, GRAPHICS AND VISUALIZATION TRACK (PROJECT OPTION) Required courses:	
CS 6610	Advanced Computer Graphics I
CS 6630	Scientific Visualization
CS 6670	Computer Aided Geometric Design
CS 6640	Image Processing
CS 6950	Independent Study (minimum three hours on project topic)
Three courses from the following list are required:	
CS 6620	Advanced Computer Graphics II
CS 6650	Image Systhesis
CS 6360	Virtual Reality
CS 6320	Computer Vision
CS 6540	Human/ Computer Interaction
CS 6960	Computational Geometry
CS 6961	Fundamentals for Visual Computing
Elective courses (to equal 30 total credit hours):	
Graduate level CS courses and independent study (a maximum of six hours of independent study is allowed). Seminars cannot be counted.	
With approval of the supervisory committee, a student may take two elective courses at the graduate level or higher from other departments, excluding independent study, seminars, research credit.	
Thesis research hours are not counted toward the degree in the project option.	

M.S. in Computing: Graphics & Visualization

COURSE REQUIREMENTS: M.S. IN COMPUTING, GRAPHICS AND VISUALIZATION TRACK (THESIS OPTION) Minimum 21 hours classroom courses and three hours of thesis research are required. Three of the following courses are required:	
CS 6610	Advanced Computer Graphics I
CS 6630	Scientific Visualization
CS 6670	Computer Aided Geometric Design
CS 6640	Image Processing
Two courses from the following list are required:	
CS 6620	Advanced Computer Graphics II
CS 6650	Image Systhesis
CS 6360	Virtual Reality
CS 6320	Computer Vision
CS 6540	Human/ Computer Interaction
CS 6960	Computational Geometry
CS 6961	Fundamentals for Visual Computing
CS 6310	Introduction to Robotics
Elective courses (to equal 30 total credit hours):	
Graduate level CS courses and independent study. Seminars cannot be counted.	
With approval of the supervisory committee, a student may take two elective courses at the graduate level or higher from other departments, excluding independent study, seminars, research credit.	
A minimum of three hours of thesis research (CS 6970) is required.	

M.S. in Computing: Data Management & Analysis

COURSE REQUIREMENTS: M.S. IN COMPUTING, DATA MANAGEMENT AND ANALYSIS Required courses: (Thesis research hours are not counted toward the degree)	
CS 6150	Algorithms
CS 6350	Machine Learning
CS 6530	Database Systems
Three courses from the following list are required:	
CS 6100	Foundations of Computer Science
CS 6210	Advanced Scientific Computing I
CS 6300	Artificial Intelligence
CS 6320	Computer Vision
CS 6340	Natural Language Processing
CS 6490	High Performance Parallel Computing
CS 6630	Scientific Visualization
CS xxxx	Applications of NLP
CS xxxx	Web Mining
CS xxxx	Advanced Databases
CS xxxx	Geometry
CS xxxx	Data Mining
Elective courses (to equal 30 total credit hours):	
Graduate level CS courses and independent study (a maximum of six hours of independent study is allowed for the project option. Only three hours may be allowed for the course-only option). Seminars cannot be counted.	
With approval of the supervisory committee, a student may take two elective courses at the graduate level or higher from other departments, excluding independent study, seminars, research credit.	

M.S. in Computing: Computer Engineering

COURSE REQUIREMENTS

The M.S. program requires 30 total semester hours of graduate coursework (including thesis hours for the thesis option). There are three options for the M.S. degree in Computer Engineering: Coursework only, project or thesis.

The M.S. Degree in Computer Engineering offers the following three options:

Coursework Option:

In this option all the course requirements are fulfilled through graduate courses (no thesis hours). No more than three hours can be Independent/ Special Studies (CS/ECE 6950).

Project Option:

Similar to the coursework option with an independent/special study on a project topic required with a project report submitted to the independent/special study advisor. A minimum of three hours and maximum of six hours of Independent/Special Studies (CS/ECE 6950) are allowed.

Thesis Option:

This option involves research on a thesis area and a written thesis submitted to the graduate school. A minimum of six thesis hours are required, and there must be at least 20 classroom hours in the program of study. A maximum of three hours of Independent/Special Studies (CS/ECE 6950) is permitted only when it is self-contained and not related to the thesis.

Two CS courses (CS 6810: Advanced Computer Architecture and CS6710: Digital VLSI) are required.

Four additional courses must be selected by students following the course only track. Project students must choose three additional electives, and thesis students should choose two electives from the provided list (page 24-25).

M.S. in Computing: Computer Engineering

Additional courses on the program of study must be approved by the student's committee.

At least 24 hours of the 30 M.S. course and thesis hours must be in resident study at the University of Utah. A full time student working on an M.S. program is expected to complete the degree requirements within two calendar years. The Graduate School limits M.S. programs to four years.

COURSEWORK CRITERIA

- A minimum GPA of 3.0 on coursework listed on the program of study with no grade lower than C- is required for graduation.
- The coursework to be taken must be approved by the student's supervisory committee.
- Courses taken as part of an undergraduate degree program may not be counted towards a graduate degree.
- A course taken for 5000-level credit cannot be taken again for 6000-level credit.
- A student that has taken one of the required courses during their B.S. degree at either the 5000 or 6000-level must take an additional restricted elective in its place.
- Where a course has both a 5000- and 6000-level number, the 5000-level version is intended for undergraduates and the 6000-level version for honors and graduate students. The two versions of the class will meet together, but extra work will be expected of honors and graduate students.
- Students may only register for thesis research after they have set up a supervisory committee.
- At most 2 credits of seminar hours can appear on a Program of Study (i.e, ECE 6900, 6910, 7900, 7910, CS 6930-6944, CS 7930-7944).
- Students in the thesis option must be enrolled with a minimum of 3 hours of credit in the semester in which they defend.
- At least one course must include a project for which a written report is produced

M.S. in Computing: Computer Engineering

COURSE REQUIREMENTS: M.S. IN COMPUTING, COMPUTER ENGINEERING Required courses:	
CS/ ECE 6810	Computer Architecture
CS/ ECE 6710	Digital VLSI Design

Elective courses: Four courses must be taken by students doing the coursework option, three courses must be taken by students doing the project option, and two courses must be taken by students doing the thesis option. Courses selected should be in an area of specialization selected by the student.	
CS 6110	Formal Methods in System Design
CS 6460	Operating Systems
CS 6470	Advanced Topics in Compilation
CS 6480	Computer Networks
CS 6962	Algorithms
CS 7460	Distributed Operating Systems
ECE 5325	Wireless Communication Systems
ECE 5520	Digital Communication Systems
ECE 6530	Digital Signal Processing
ECE 6580	Implementation of Digital Signal Processing Systems
ECE 7530	Advanced Digital Signal Processing I
ECE 7531	Advanced Digital Signal Processing II
CS/ ECE 6720	Analog Integrated Circuit Design
CS/ ECE 6740	Computer-Aided Design of Digital Circuits

M.S. in Computing: Computer Engineering

Computer Engineering Track Elective courses: Continued	
CS/ ECE 6745	Testing and Verification of Digital Circuits
CS/ ECE 6750	Synthesis and Verification of Async. VLSI Systems
CS/ ECE 6770	Advanced Digital VLSI Systems Design
CS/ ECE 6780	Embedded System Design
CS/ ECE 6785	Advanced Embedded System Design
CS/ ECE 6830	VLSI Architecture
CS/ ECE 7810	Advanced Architecture
CS/ ECE 7820	Parallel Architecture

Ph.D. Degree Guidelines

PH.D. DEGREES OPTIONS

The SoC offers two Ph.D. degrees, one in Computer Science, and one in Computing. There are currently a Robotics track, a Graphics and Visualization track, and a Scientific Computing track, Computer Engineering track and Data Management and Analysis track available in Computing.

Courses that count toward graduation for the Computer Science degree must be on the program of study. The following restrictions apply to these courses:

- CS courses must have a course number of 6000 or above, or must be CS 6460 (Operating Systems) or CS 5470 (Compiler Principles and Techniques)
- non-CS courses must have a course number of 5000 or above;
- they must have a grade of B- or better;
- the GPA for all these courses must be at least 3.0.

For required courses, this additional restriction applies:

- the GPA for all these classes must be at least 3.5.

RESIDENCY

At least one year (i.e., two consecutive semesters) of the doctoral program must be spent in full-time academic work at the University of Utah. When a student proceeds directly from an M.S. degree to a Ph.D. degree with no break in the program of study (except for authorized leaves of absence), the residency requirement may be fulfilled at any time during the course of study.

CREDIT FOR PREVIOUS COURSES

PhD students may count some hours of coursework from other graduate degrees toward the coursework requirements associated with the program of study. Unlike for the MS programs, credit for previous courses for PhD students is administered by the DGS so these courses do not need to be be officially transferred to the University. Approved courses are certified by inclusion of the appropriate SoC form in the student's file. All coursework on the program of of study is subject to approval by the student's supervisory committee and the DGS.

Ph.D. students with a masters-level degree in a closely related discipline should work with their initial committee to create a program of study that can include graduate courses taken as part of their previous degree program. This program of study can include up to twenty total hours to be counted toward their Ph.D. requirements, and

Ph.D. Degree Guidelines

can be used to satisfy some or all of the Ph.D. required courses. Like all programs of study, it must then be approved by the DGS and the graduate school.

A student who has been accepted by the Graduate School is formally admitted to candidacy for the Ph.D. by the University at the recommendation of the student's supervisory committee. Admission to candidacy occurs after the student:

- forms a supervisory committee,
- files an approved Program of Study form,
- completes the core course requirements,
- passes the written portion of the qualifying examination, and
- passes the oral portion of the qualifying examination

An application for candidacy must be submitted to the Graduate School no later than two months prior to the semester of graduation. For the degree to be conferred, the approved Program of Study form must be completed and the dissertation completed and publicly defended.

A Ph.D. Supervisory Committee conducts the student's written qualifying examination, oral qualifying examination, and dissertation defense. This committee consists of five faculty members, at least three of whom must be from the SoC, and at least one member from outside the SoC. Any SoC regular faculty member may serve as a supervisory committee chair. Research or adjunct faculty may chair supervisory committees if accorded that privilege by the regular faculty. Individuals who are not faculty members may serve on supervisory committees if nominated by the regular faculty on the committee, and endorsed by the Graduate Studies Committee and School Director. For Computing degrees, further restrictions on committee makeup may apply. All official decisions of the committee are decided by majority vote.

QUALIFYING EXAMINATION

All Ph.D. students must pass a Qualifying Examination, as specified by the Graduate School. The Qualifying Exam consists of a written part, to be conducted first, and an oral part. The written part of the Qualifying Examination will cover the candidate's general area of specialization in sufficient depth to demonstrate their preparation for conducting Ph.D.-level research. Each internal member of the student's supervisory

committee will contribute one or more questions to this exam. The external member(s) of the committee can provide question(s) if they wish to. The supervisory committee will provide a written evaluation of this part of the exam, including an indication of whether or not the student will be allowed to proceed to the oral part of the Qualifying Examination. More details on the procedures for the written part is available on the GSC web page.

The oral part comprises the dissertation proposal defense. At the supervisory committee's option, it may also include follow-up questions relating to the written part of the exam. A majority of the supervisory committee should certify that the proposal is ready to be defended prior to conducting the oral part of the Qualifying Exam.

DISSERTATION

The completed dissertation must be published either in its entirety (through a legitimate publisher of the student's choice or through University Microfilms) or as one or more articles accepted for publication in approved scholarly journals. An abstract of each dissertation must be published in University Microfilms' Dissertation Abstracts International.

STUDENT PROGRESS: TERMINOLOGY

Initial committee: This consists of two University of Utah faculty members and an advisor, who must meet the School of Computing requirements for advising. The initial committee is dierent from the full committee, who will ultimately administer the qualier and evaluate the dissertation. The full committee must be chosen to conform to program requirements. The initial committee is automatically dissolved when the student forms a full committee.

Good vs acceptable progress: Students completing milestones within the time frame denoted as "good" are generally considered to be in good standing in the program. Students completing milestones within the time frame denoted as "acceptable" are considered to be making acceptable progress in the program and are encouraged to continue on and attempt to meet successive milestones within the time frames denoted as "good."

Such students may or may not be considered in good standing, depending upon evaluation of the director of graduate studies (DGS) with input from their advisor and advisory committee. Students not completing milestones within the time frame denoted as "acceptable" are not considered in good standing.

Ph.D. Degrees

GRADUATE STUDENT PROGRESS GUIDELINES FOR THE PH.D. PROGRAM

Milestone	Good Progress	Acceptable Progress	Comments
Choose advisor and initial committee	2 Semesters	2 Semesters	
Program of study approved by advisor and initial committee	2 Semesters	3 Semesters	
Complete required courses	3 Semesters	5 Semesters	Program requirement: 5 semesters
Full committee formed	4 Semesters	5 Semesters	
Program of study approved by committee	4 Semesters	5 Semesters	U. requirement: 1 semester before defense
Written qualifier	5 Semesters	6 Semesters	U. requirement: 1 semester before defense
Oral qualifier (proposal)	5 Semesters	7 Semesters	U. requirement: After written qualifier and 1 semester before defense
Dissertation defense	9 Semesters	12 Semesters	
Final document			U. requirement: 1 semester before defense

Ph.D. in Computer Science

At least 50 hours of graduate coursework is required for the Ph.D. degree in computer science. This must be composed of at least 27 hours of regular graduate coursework, and at least 14 semester hours of dissertation research. Independent study and seminars cannot be used as part of the required 50 hours. Of the required 27 semester hours of regular courses, up to six may be graduate courses outside of CS. Up to 20 hours of coursework taken elsewhere or counted toward previous degrees can be counted toward the 27 hour regular course requirement with the approval of the GSC. Ph.D. students must demonstrate core knowledge in computer science by fulfilling the following requirements:

COURSE REQUIREMENTS: PH.D. IN COMPUTER SCIENCE

Students should select one course from each of the three categores. Three of these courses are required for students in both the thesis and non-thesis tracks.

CATEGORY #1	
CS 6100	Foundations of Computer Science
CS 6150	Algorithms
CATEGORY #2	
CS 6460	Operating Systems *
CS 6480	Computer Networks
CS 7460	Advanced Operating Systems
CATEGORY #3	
CS 6810	Advanced Computer Architecture *
CS 6710	Digital VLSI Design
CS 6720	Advanced Integrated Circuit Design
CS 6740	CAD of Digital Circuits
CS 6770	Advanced Digital VLSI Systems Design
CS 6830	VLSI Architecture
CS 7820	Parallel Computer Architecture

* Suggested course

Ph.D. in Computer Science

Students not doing a thesis must also take at least two courses from the following six choices:	
CS 5470	Compiler Principles and Techniques
CS 6210	Advanced Scientific Computing
CS 6300	Artificial Intelligence
CS 6480	Computer Networks
CS 6530	Database Systems
CS 7520	Programming Languages and Semantics
The following may also be used to fulfill this requirement:	
CS 6220	Advanced Scientific Computing II
CS 6350	Machine Learning
CS 6470	Advanced Topics in Compilation
CS 6510	Functional Programming
CS 6785	Advanced Embedded Systems
CS 7120	Information Based Complexity
CS 7460	Advanced Operating Systems
CS 7820	Parallel Computer Architecture

Students may not place out of these requirements by substituting or transferring courses from other institutions. However, with approval of the Graduate Studies Committee, a student may replace one or more of these courses with a more advanced course offered by the School of Computing in the same or related subject areas. Substitute courses must be regular classes with exams and/or assignments, not seminar, readings, or independent study classes. There is a list of pre-approved substitutions listed on the GSC web page. Each advanced course can be offered as a substitute for only one required course. At most nine credits of the 27 semester hours of regular graduate course work required of Ph.D. candidates can consist of CS5460, CS6100, CS6810, CS5470, CS6210, CS6480, CS7520, i.e., the seven courses listed above. Substitute courses are not subject to this nine credit limit.

Ph.D. in Computing: Robotics

COURSE REQUIREMENTS: PH.D. IN COMPUTING, ROBOTICS TRACK 50 hours of graduate coursework is required, composed of at least 27 hours of regular graduate coursework, and at least 14 semester hours of dissertation research. Up to 20 hours of previous coursework can be counted toward the 27 hour regular course requirement with the approval of the GSC. The following three courses are required:	
CS 6310 / ME 6220	Introduction to Robotics
CS 6960	Introduction to Robot Control
CS 6370	Geometric Computation for Motion Planning
One course from each of these three areas are required, plus at least one additional course from any area of interest:	
PERCEPTION	
CS 6320	Computer Vision
CS 7640	Image Processing for Graphics and Vision
COGNITION	
CS 6300	Artificial Intelligence
CS 6350	Machine Learning
CS 6330	Multiagent Systems
ACTION	
CS 6360	Virtual Reality
CS 7310/ ME 7230	Advanced Manipulation and Locomotion
CS 7370	System Indentification for Robotics
CS 7200	Nonlinear Controls
ME 6960	Advanced Mechatronics
ME 7939	Seminar in Robotics
Two additional 6000-level courses are required (excluding independent study, seminars, or thesis research credit).	

Ph.D. in Computing: Scientific Computing

COURSE REQUIREMENTS: PH.D. IN COMPUTING, SCIENTIFIC COMPUTING TRACK

50 hours of graduate coursework is required, composed of at least 24 hours of regular graduate coursework, and at least 14 semester hours of dissertation research. Of the required 24 semester hours of regular courses, up to six may be graduate courses outside of CS. Up to 12 hours of coursework taken elsewhere or counted toward previous degrees can be counted toward the 24 hour regular course requirement with the approval of the GSC. The following four courses are required:

CS 6210	Advanced Scientific Computing I
CS 6220	Advanced Scientific Computing II
CS 6230	High-Performance Computing and Parallelization
CS 6630	Scientific Visualization

In addition, a student must take four elective courses which involve the themes of scientific computing or are directly applicable to the student's dissertation research. The following is the list of those classes which will apply:

CS 6100	Foundations of Computer Science
CS 6530	Database Systems
CS 6650	Image Synthesis
CS 6610	Advanced Computer Graphics
CS 6810	Advanced Computer Architecture
CS 7120	Information-Based Complexity
CS 7210	Advanced Topics in Scientific Computing
CS 7450	Simulation Methods

Additional 6000-level courses may be required to reach a 50-credit minimum (excluding independent study, seminars, or thesis research credit).

Ph.D. in Computing: Graphics & Visualization

COURSE REQUIREMENTS: PH.D. IN COMPUTING, GRAPHICS AND VISUALIZATION TRACK Students must choose at least three of these four specific courses:	
CS 6610	Advanced Computer Graphics I
CS 6630	Scientific Visualization
CS 6670	Computer Aided Geometric Design
CS 6640	Image Processing

Course work listed on the approved Program of Study form must comprise at least 50 semester hours of graduate course work and dissertation research, exclusive of independent study. Graduate course work applied toward an M.S. degree may be included. At least 14 semester hours of dissertation research (CS 7970) and 30 semester hours of graduate course work must be included. Up to 12 hours of graduate level course work already applied to other degrees may be used in the program of study.

Required Courses: PhD students must demonstrate core knowledge in computer graphics and visualization by passing three courses from a choice of four, prior to the start of their fifth semester of study, with grades of B or better in each course and an overall GPA in the specified courses greater than 3.5. Students may place out of this requirement by substituting or transferring courses from other institutions.

Substitute courses must be "regular" classes with exams and/or assignments, not seminar, readings, or independent study classes.

Satisfactorily completing the three courses as described constitutes completion of the Comprehensive exam; this must be completed by the the end of the fourth semester.

Ph.D. in Computing: Graphics & Visualization

ELECTIVE COURSES School of Computing Computer Science courses on the Program of Study must be at the 6000 level or above, excluding independent study, and research credits. Of the required 30 semester hours, up to nine credit hours may be graduate courses outside of the School of Computing. Admissible elective courses within the School of Computing are the following:

CS 6620	Advanced Computer Graphics II
CS 6310	Introduction to Robotics
CS 6360	Virtual Reality
CS 6210	Advanced Scientific Computing I
CS 6220	Advanced Scientific Computing II
CS 6960	Computational Geometry
CS 6540	Human/ Computer Interaction
CS 6630	Scientific Visualization
CS 7320	Computer Vision
CS 7650	Realistic Image Synthesis
CS 6680	Computer-Aided Geometric Design II
CS 7310	Advanced Robotics
CS 7961	Vision Science

Courses not on the list above must be approved by the student's committee to count toward the elective requirements. Independent study (CS 6950 and CS 7950) can not be included in the Program of Study for the PhD degree.

Ph.D. in Computing: Computer Engineering

COURSE REQUIREMENTS

A Ph.D. student must either already have an M.S. degree or complete all of the requirements for a course, project, or thesis-based M.S. degree in CE. The supervisory committees may require additional coursework hours above that required for the M.S. degree.

All students must complete at least seven hours of coursework at the University of Utah. All students must complete at least 14 hours of dissertation research (CS or ECE 7970). At least one year (i.e. two consecutive semesters) of the doctoral program must be spent in full-time academic work at the University of Utah. A student must be registered for at least three hours of credit in the semester that they defend their dissertation.

SUPERVISORY COMMITTEE

Each CE graduate student must form a supervisory committee whose members approve the student's program of study and guides the student's research program. A Ph.D. committee consists of five members. The majority of the committee must consist of CE faculty from either ECE or SoC. Ph.D. students are strongly encouraged to have a member of the committee who is outside the University of Utah whenever it is feasible. The committee should be formed by the end of the second semester of enrollment in the graduate program, although a committee may be revised later by petition to the CE committee.

Any ECE or SoC regular faculty member may serve as a supervisory committee chair. Auxiliary faculty may chair supervisory committees if accorded that privilege by the regular faculty and the Dean of the Graduate School. Individuals who are not faculty members may serve on supervisory committees if nominated by the regular faculty on the committee, and endorsed by the CE Committee. The Dean of the Graduate School must grant final approval of all supervisory committees.

Ph.D. in Computing: Computer Engineering

The supervisory committee is required to monitor the student's progress. The student is subject to removal from the program if a student's supervisory committee finds that the student is not making satisfactory progress.

COURSE REQUIREMENTS: PH.D. IN COMPUTING, COMPUTER ENGINEERING Required courses:	
CS/ ECE 6810	Computer Architecture
CS/ ECE 6710	Digital VLSI Design
CS/ ECE 6780	Embedded System Design
Two additional courses are required from the following list:	
CS 6470	Advanced Topics in Compilation
CS 6490	Network Security
CS/ ECE 6770	Advanced Digital VLSI Systems Design
CS/ ECE 6785	Advanced Embedded System Design
CS 6110	Formal Methods in System Design
CS/ ECE 7810	Advanced Architecture
CS 7460	Distributed Operating Systems

Ph.D. in Computing: Data Management & Analysis

COURSE REQUIREMENTS

Course work listed on the approved Program of Study form must comprise at least 50 semester hours of graduate course work and dissertation research, exclusive of independent study. At least 14 semester hours of dissertation research (CS 7970) and 24 semester hours of graduate course work must be included. Up to 12 hours of graduate level course work already applied to other degrees may be used in the program of study as approved by the TCF Chair.

REQUIRED COURSE/ COMPREHENSIVE EXAM

Ph.D. students must demonstrate core knowledge in the area of information by passing three specified courses, prior to the start of their fifth semester of study, with grades of B or better in each course and an overall GPA in the specified courses of at least 3.5. This requirement constitutes the Comprehensive Exam.

COURSE REQUIREMENTS: PH.D. IN COMPUTING, DATA MANAGEMENT AND ANALYSIS

Required courses (Students may place out of this requirement by substituting or transferring courses from other institutions at the discretion of the TCF Chair):

CS 6150	Algorithms
CS 6350	Machine Learning
CS 6530	Database Systems

ELECTIVE COURSES

A student must take five elective courses (fifteen hours) which involve the areas related to information, or are directly applicable to the student's dissertation research. Up to three courses (nine hours) may be taken from other departments at the University of Utah. All elective courses on the Program of Study must be taught at the graduate level. For those classes taken within the School of Computing, it is advised that students take 6000 level courses and above when available/appropriate. All courses taken by a track student to fulfill the elective requirements must be approved by the student's committee and the TCF Chair.

Ph.D. in Computing: Data Management & Analysis

ELECTIVE COURSES Five courses from the following list are required:	
CS 6100	Foundations of Computer Science
CS 6210	Advanced Scientific Computing I
CS 6300	Artificial Intelligence
CS 6320	Computer Vision
CS 6340	Natural Language Processing
CS 6490	High Performance Parallel Computing
CS 6630	Scientific Visualization
CS xxxx	Applications of NLP
CS xxxx	Web Mining
CS xxxx	Advanced Databases
CS xxxx	Geometry
CS xxxx	Data Mining

ADDITIONAL ELECTIVES

The following list contains some of the possible elective courses from outside the School which a student may take to fulfill elective requirements:

- MATH 5010 Introduction to Probability
- MATH 5080 Statistical Inference I
- MATH 5090 Statistical Inference II
- MATH 5250 Matrix Analysis
- MATH 6010 Linear Models
- MATH 6020 Multilinear Models
- MATH 7870 Methods of Optimization
- ECE 5510 Random Processes
- ECE 6540 Estimation Theory
- ECE 6520 Information Theory and Coding
- ECE 6551 Survey of Optimization Techniques
- IS 6481 Data Warehousing
- IS 6482 Data Mining
- BMI 6010 Foundations of Medical Informatics
- BMI 6020 Foundations of Bioinformatics and Genetic Epidemiology
- BMI 6105 Statistics for Biomedical Informatics
- BMI 6300 Medical Decision-Making

Computer Science Courses

The number and title of each course is followed by the number of semester hours it carries, the semester(s) during which it is taught (F=fall, S=spring, U=summer), its pre-requisites, its co-requisites, and any courses with which it is cross-listed.

Where a course has both a 5000-and 6000-level number, the 5000-level version is intended for undergraduates, and the 6000-level version is for honors and graduate students. The two versions of the class will meet together, but extra work will be expected of honors and graduate students. Additional credit toward the bachelor's degree will not be given for taking a 6000-level course after taking the 5000-level version. Courses that have only 6000-level numbers may be taken by graduate and advanced undergraduate students.

Some elective classes are not offered every year. Check the online schedule or talk to the computer science academic advisor to see which classes will be offered in upcoming semesters. For a complete list of courses and course descriptions, visit the School of Computing online at www.cs.utah.edu.

COURSE/ CREDITS/ SEMESTER OFFERED/ PREREQS
F=Fall, S=Spring, U=Summer

1000 Engineering Computing/ 3/ FS/ Coreq: CS 1010, MATH 1210
1001 Engineering Computing using MATLAB /1.5/ FS/ Coreq: CS 1010, MATH 1210
1010 Introduction to Unix/ 0.5/ FSU
1020 Introduction to Programming in C++/ 3
1021 Introduction to Programming in Java/ 3
1040 Creating Interactive Web Content/ 3/ FS
1050 Computers in Society/ 3, FS
1060 Explorations in Computer Science/ 3/ FS
1410 Introduction to Computer Science I/ 4/ FS/ Coreq: MATH 1210, CS 1010
2000 Introduction to Programming in C/ 4/ F/ Coreq: MATH 1210, CS 1010
2100 Discrete Structures/ 3/ F/ Prereq: CS 1410
2420 Introduction to Computer Science II/ 4/ SU/ Prereq: CS 1410
3010/3011 Industry Forum/ 1/ F
3100 Models of Computation/ 3/ F/ Prereq: CS 2420, CS 2100
3130 Engineering Probability and Statistics/ 3/ F/Prereq: Math1220
3200 Scientific Computation/ 3/ S/ Prereq/ CS 2420, MATH 2210
3500 Software Practice I/ 4/ F/ Prereq: CS 2420
3505 Software Practice II/ 3/ S/ Prereq: CS 3500
3650 3D Modeling for Video Games and Machinima/ 3/ F
3660 Interactive Machinima/ 3 / S
3700 Fundamentals of Digital System Design/ 4/ S, Prereq: CS 1410, PHYCS 2220

Computer Science Courses

3710 Computer Design Laboratory/ 3/ F/ Prereq: CS/ECE 3700, CS/ECE 3810
3810 Computer Organization/ 4/ F/ Prereq: CS 2420 or CS 2000
3950 Independent Study/ 1–4
3960 Special Topics/ 1–4/
3991 Computer Engineering Junior Seminar/ 0.5/ F/ Prereq: CE major status
3992 CE Pre-Thesis/Pre-Project/ 1/ S/ Prereq: CS/ECE 3710, 3991, CE major status
4005 Honors Research Practice/ 3/ S/ Prereq: CS 3500 and admission to CS Honors track
4010 Teaching Introductory Computer Science/ 1/ FS/ Prereq: Permission of instructor
4150 Algorithms/ 3/ S/ Prereq: CS 2100, CS 3500
4400 Computer Systems/ 4/ F/ Prereq: CS 3500, CS 3810
4500 Software Engineering Laboratory/ 3/ S/ Prereq: CS 3505, senior standing in CS
4540 Web Software Architecture/ 3/ S/ Prereq: CS 3505
4550 Simulation/ 3/ F/ Prereq: CS 3505
4710 Computer Engineering Senior Project/ 3/ F/ Prereq: CS/ECE 3710, 3992, 5780
4950 Independent Study/1–4
4960–4964 Special Topics/1–4
4970 Computer Science Bachelors Thesis/ 3/ Prereq: Senior standing in CS
4991 CE Senior Thesis I/ 2/ F/ Prereq: CS/ECE 3992 and approved senior thesis proposal
4992 Computer Engineering Senior Thesis II/ 2/ S/ Prereq: CS/ECE 4991
5010 Software Practice I/ 4/ F/ Prereq: CS 2420 and permission of instructor
5020 Software Practice II/ 3/ S/ Prereq: CS 5010 and permission of instructor
5100 Foundations of Computer Science/ 3/ S/ Prereq: CS 3100, CS 4150
5150 Advanced Algorithms/ 3/ F/ Prereq: CS 4150, CS 3130, Math 1220
5160 Computational Geometry/ 3/ Prereq: CS 4150 or 5150
5300 Artificial Intelligence/ 3/ S/ Prereq: CS 3505
5310 Robotics/ 3/ F/ Prereq: CS 1000, MATH 2250, PHYCS 2210
5320 Computer Vision/ 3/ F/ Prereq: CS 3505, MATH 2210, MATH 2270
5340 Natural Language Processing/ 3/ F/ Prereq: CS 3505
5350 Machine Learning/ 3/ F/ Prereq: CS 2100, CS 2420; CS 5300 recommended
5460 Operating Systems/ 4/ F/ Prereq: CS 4400
5470 Compiler Principles and Techniques/ 4/ S/ Prereq: CS 3100, CS 4400
5480 Computer Networks/ 3/ F/ Prereq: CS 4150, CS 4400
5510 Programming Language Concepts/ 3/ F/ Prereq: CS 3500
5520 Anatomy of a Modern Programming Language/ 3/ S/ Prereq: CS 5510
5530 Database Systems/ 3/ F/ Prereq: CS 3500
5600 Introduction to Computer Graphics/ 3/ S/ Prereq: CS 3500, MATH 2250 or 2270
5610 Interactive Computer Graphics/ 3/ F/ Prereq: CS 5600
5630 Scientific Visualization/ 3/ F/ Prereq: CS 3505; CS 3200 or CS 6210 or MATH 5600
5710 Digital VLSI Design/ 4/ F/ Prereq: CS 3700, CS 3810 recommended
5720 Analog Integrated Circuit Design/ 3/ S/ Prereq: ECE 3110
5740 Computer-Aided Design of Digital Circuits/ 3/ S/ Prereq: CS/ECE 3700, CS 4150
5745 Testing and Verification of Digital Circuits/ 3/ Prereq: ECE/CS 3700

Computer Science Courses

5750 Synthesis,Verification of Asynchronous VLSI Systems/ 3/ Prereq: CS/ECE 3700, 3505
5780 Embedded System Design/ 4/ S/ Prereq: CS/ECE 3810, CS 2000 or 4400
5785 Advanced Embedded Systems/ 4/ F/ Prereq: CS/ECE 5780
5830 VLSI Architecture/ 3/ S/ Prereq: CS/ECE 3700, CS/ECE 3810
5950 Independent Study/ 1–4
5960–5969 Special Topics/ 1–4
6020 Conducting, Presenting Early-Career Research/ 3/ Prereq: Grad standing in CS
6100 Foundations of Computer Science/ 3/ S/ Prereq: CS 3100, CS 4150
6110 Formal Methods for System Design/ 3/ S/ Prereq: CS 5100/6100
6210 Advanced Scientific Computing I/ 3/ F/ Prereq: CS 3200, CS 3505, MATH 3150
6220 Advanced Scientific Computing II/ 3/ S/ Prereq: CS 6210 or MATH 5600
6230 High Performance Parallel Computing/ 3/ S/ Prereq: Programming in C/C++
6300 Artificial Intelligence/ 3/ S/ Prereq: CS 3505
6310 Robotics/ 3/ F/ Prereq: CS 1000, MATH 2250, PHYCS 2210
6320 Computer Vision/ 3/ S/ Prereq: CS 3505, MATH 2210, MATH 2270
6340 Natural Language Processing/ 3/ F/ Prereq: CS 3505
6350 Machine Learning/ 3/ F/ Prereq: CS 2100, CS 2420; CS 6300 recommended
6360 Virtual Reality/ 3/ S/ Prereq: CS 5310/6310
6370 Geometric Computation for Motion Planning/ 3/ F/ Prereq: CS 1020, MATH 2250
6380 Multiagent Systems/ 3/ S/ Prereq: See instructor
6460 Operating Systems/ 4/ F/ Prereq: CS 4400
6470 Advanced Topics in Compilation/ 3/ F/ Prereq: CS 5470
6480 Computer Networks/ 3/ F/ Prereq: CS 4150, CS 4400
6490 Network Security/ 3/ S/ Prereq: CS 5480/6480
6510 Functional Programming/ 3/ F/ Prereq: CS 3100, CS 5510
6530 Database Systems/ 3/ F/ Prereq: CS 3500
6540 Human/Computer Interaction/ 3/ F/ Prereq: CS 3500
6610 Advanced Computer Graphics I/ 3/ F/ Prereq: CS 5600
6620 Ray Tracing/ 3/ S/ Prereq: CS 5610/6610
6630 Scientific Visualization/ 3/ F/ Prereq: CS 3505; CS 3200 or CS 6210 or MATH 5600
6640 Image Processing/ 3/ S/ Prereq: CS 2420, MATH 2250
6670 Computer-Aided Geometric Design I/ 3/ F/ Prereq: MATH 2210, 2250, CS 3505
6680 Computer-Aided Geometric Design II/ 3/ Prereq: CS 6670
6712 Digital IC Projects Testing/ 1/ F/ Prereq: CS/ECE 6710
6720 Advanced Integrated Circuit Design II/ 3/ S/ Prereq: ECE 3110
6721 Analog Integrated Circuits Lab/ 1/ S/ Coreq: CS 6720
6722 Analog Integrated Circuits Project Testing/ 1/ F/ Prereq: CS/ECE 6720
6740 Computer-Aided Design of Digital Circuits/ 3/ S/ Prereq: CS/ECE 3700, CS 4150
6750 Synthesis,Verification of Asynchronous VLSI Systems/ 3/ F/ Prereq: CS3700, 3505
6760 Modeling, Analysis of Biological Networks/ 3/ F/ Prereq: See instructor
6770 Advanced Digital VLSI Systems Design/ 3/ Prereq: CS6710, instructor permission
6780 Embedded System Design/ 4/ S/ Prereq: CS/ECE 3810, CS 2000 or 4400

Computer Science Courses

6785 Advanced Embedded Systems/ 4/ F/ Prereq: CS/ECE 5780/6780
6810 Computer Architecture/ 3/ F/ Prereq: CS/ECE 3810
6830 VLSI Architecture/ 3/ S/ Prereq: CS/ECE 3700, CS/ECE 3810
6960–6969 Special Topics/ 1–4
7010 Writing Research Proposals/ 2/ S/ Prereq: Graduate standing in Computer Science
7120 Information-Based Complexity/ 3/ Prereq: CS 3200, MATH 2270, MATH 3210
7240 Sinc Methods/ 3/ S/ Prereq: CS 6210 or MATH 5600 or MATH 5610
7250 Advanced Topics in Scientific Computing/ 3/ F/ Prereq: CS 6220
7310 Advanced Manipulation and Locomotion/ 3/ Prereq: CS 6310 or ME 6220
7320 System Identification for Robotics/ 3/ Prereq: CS 5310/6310 or ME EN 5220/6220
7460 Distributed Operating Systems/ 3/ Prereq: CS 5460, CS 5480/6480
7520 Programming Language Semantics/ 3/ S/ Prereq: CS 3100, CS 5510
7650 Realistic Image Synthesis/ 3/ F/ Prereq: CS 6620, CS 6670, MATH 5010
7810 Advanced Computer Architecture/ 3/ S/ Prereq: CS/ECE 6810
7820 Parallel Computer Architecture/ 3/ S/ Prereq: CS/ECE 6810
7960–7969 Special Topics/ 1–4

School of Computing

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