Request to move the   
  
Bachelor of Arts in   
Information and Computer Sciences,   
University of Hawaii at Manoa,   
  
From Provisional to Established Status   
  
Fall 2011

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This self-study report is organized according to the “Guidelines for Assessment of Provisional and Established Programs” E5.201.

# Introduction

About one-third of the economic growth in the U.S. in the last decade has been in information and computing technology. While the Internet and the Web are perhaps the most visible aspects of this change, the revolution is pervasive, touching nearly every field and discipline, from computational techniques in the physical and biological sciences, to new interactive media in the fine arts. The impact of the digital and information revolution upon society has been profound. The evolution of computing and information technology will continue to be a driving force behind the creation of new industries, careers, and academic disciplines. As a result, there is a genuine and increasing need for workers with an interdisciplinary background who understand the social and organizational uses of technology and who are literate and articulate. They require knowledge of computing systems, global communications networks, and interactive information resources. The requisite proficiencies go beyond being comfortable with computing tools. They require the ability to apply computational ways of thinking to design, to writing, to experimentation, to artistic expression, and to problem solving

The mission of the Department of Information and Computer Sciences (ICS) is to: (1) develop leading edge research that fuels economic and entrepreneurial advances, prepares information and technologically literate citizens, and drives technological improvements in curriculum and teaching and (2) provide professional education for students specializing in computer science and basic computer science education for all interested students.

In Fall 1998, ICS received provisional approval to offer the Bachelor of Arts (BA) degree. According to University guidelines, provisional programs should be evaluated for transition to permanent status after five years. Therefore, the ICS BA program should have been evaluated in 2003. The current Department Chair and Associate Chair do not know why the evaluation did not occur in a timely manner, and both the Department Chair and Associate Chair from that time are no longer with the Department. In fact, we learned only this summer that this report was overdue, at which point we began immediately to work on rectifying the situation. We apologize for this extreme and inappropriate delay in completing this evaluation.

# Assessment of program organization and objectives

Is the program organized to meet its objectives? (Discussion of curriculum, requirements, admissions, advising and counseling, and other aspects of the program, with reference to the objectives.)

## Overview of Information and Computer Sciences

The Department of Information and Computer Sciences is part of the College of Natural Sciences at the University of Hawaii at Manoa. The Information and Computer Sciences (ICS) Department offers four academic degrees:

* Bachelor of Arts in Information and Computer Sciences (approved as provisional in 1998)
* Bachelor of Science in Computer Science (approved in 1974)
* Master of Science in Information and Computer Sciences (approved in 1968)
* PhD in Computer Science (approved as provisional in 1997)

The ICS Department is also essential in the delivery of three other degrees in conjunction with other departments on campus:

* Professional Master Degree Program in Library and Information Science (approved 1969)
* Bachelor of Science in Computer Engineering (approved as provisional in 2009)
* PhD in Communication and Information Sciences, Interdisciplinary (approved in 1986)

A minor in Computer Science is available for students who would like to develop a solid foundation in computer science in conjunction with their major degree program.

These joint programs are vital for the department’s mission, for service to the students, as well as for campus collaboration and support. As a result, the evaluation of the ICS program should not be based only on degree offerings or graduation metrics, since the department provides many service courses to other programs and degrees.

For example, the Bachelor of Science in Computer Engineering (BSCE) was approved by the Board of Regents as a provisional program in November 2009 through the College of Engineering. For this degree, ICS provides the Discrete Math curriculum and up to 6 credits of technical electives. This illustrates the importance of the service courses offered by ICS to other departments.

As another example, the ICS department offers hundreds of seats each year to students looking to fulfill one or more of their general education and/or focus requirements through the ICS program. These course offerings are large and serve a diverse campus population. The department has also created Honors sections for select students in various disciplines.

The chart below shows the total number of majors and degrees awarded broken down by the different degrees offered by the ICS department.







Appendix A provides a complete listing of ICS undergraduate courses.

## The Bachelor of Arts in Information & Computer Sciences

The Bachelor of Arts degree program allows ICS students to combine computer science with other disciplines, giving them the opportunity to explore the ways computers, networks and mobile devices affect society. Our B.A. students can contribute to collaborative interdisciplinary teams and have the program flexibility to apply this knowledge to areas beyond traditional computer science programs.

The curriculum for a BA in ICS was developed by the ICS faculty in response to numerous student and industry requests for a flexible undergraduate major that would allow students to develop expertise in both computer science and other subject areas. The faculty defined a program that blends the requirements of a strong computer science core with the flexibility of a liberal arts education. Students earning the B.A. degree in ICS will be particularly attractive to technical organizations that desire people with strong written and oral communication skills.

Upon completion of the BA program, student will be able to:

* Use current technical concepts and practices in software development, computer networking, databases, and web related technologies,
* Manage all aspects of solving computer-based problems involving requirements analysis, design, implementation, and project management,
* Participate in collaborative team oriented activities,
* Communicate effectively using modem technologies, using oral, written, and web media.

The BA in ICS degree is unique in its ability to allow students to combine computer science with another discipline. Many of the BA courses are also taken by students pursuing the BS in ICS, however the BA allows for more electives and customization. It is the careful selection of electives that allows students to customize their degree and their future job opportunities in such diverse areas as business information systems, educational development environments, and multimedia entertainment systems. An academic plan handout is available for students as an advising tool, which is located in Appendix A of this document.

### Curriculum

Students must complete the Bachelor of Arts General Education Core, which is described in the General and Graduate Information Catalog. For the major requirements, BA students must complete:

* Required courses: ICS 111/L, 141, 211, 212, 241, 311, 312, 313, 321
* Junior/senior electives: three ICS (or approved) 400-level courses, including at most three credits of ICS 499 and three credits of ICS 491.
* Area concentration electives: four upper division (300-level or above) courses in some area of concentration (e.g., art, business, music, education).

Appendix B presents a standard course plan showing how students can progress through our B.A. curriculum and graduate in eight semesters.

Students seeking a BA must write a proposal, of one page or less, specifying the seven courses they will use for their ICS and area concentration electives. All seven electives and this course proposal must be approved by an ICS undergraduate advisor. The proposal explains how these courses form a coherent plan of study combining computer science with another field. Some examples of recent proposals include:

I want to work in computer games programming, which requires art/drawing, computer graphics, and software engineering skills. ICS electives: ICS 481 Intro. to Computer Graphics, ICS 413 Software Engineering I, ICS 414 Software Engineering II. Area electives: ART 313 Advanced Drawing, ART 322 Advanced Color, ART 363 Design: Studio 2, ART 309 Image in Motion Studio II.

I want to do machine translation of Japanese and English, which requires artificial intelligence, cognitive science, and Japanese language skills. ICS electives: ICS 361 Artificial Intelligence I, ICS 461 Artificial Intelligence II, ICS 464 Intro. to Cognitive Science. Area electives: JPN 301 Third-Year Japanese, JPN 302 Third-Year Japanese, JPN 350 Intro. to Japanese Linguistics, JPN 425 Japanese Translation.

I want to create web pages, which requires hypermedia, databases, and graphic design skills. ICS electives: ICS 465 Intro. to Hypermedia, ICS 665 User Interfaces & Hypermedia (3.0 GPA required), ICS 421 Database Systems. Area electives: ART 363 Design: Studio 2, ART 364 Design: Studio 3, ART 465 Design: Typography 3, ART 322 Advanced Color.

I want to use computers to predict the stock market, which requires statistics, databases, and business skills. ICS electives: ICS 442 Analytical Models & Methods, ICS 471 Probability, Statistics, & Queuing, ICS 421 Database Systems. Area electives: BUS 310 Statistical Analysis for Business Decisions, BUS 311 Information Systems for Global Business Environment, BUS 316 Quantitative Business & Economic Analysis, BEC 389 Applied Business Economics: Forecasting.

Since 2002, the department has increased the number of advanced undergraduate level offerings focused on the BA options. Of course, these emerging topics are also of great interest for students pursuing the BS degree.

In addition to allowing students to build their own degree paths, we have defined two explicit B.A. degree focus areas: the Bioinformatics focus area and the Information Assurance and Computer Security focus area.

(START HERE)

### Focus area: Bioinformatics

Students seeking the BA in ICS with a Bioinformatics focus must have an appropriate bioscience degree or also earn a minor in Biology. These requirements include the following:

**BA in ICS**

* ICS 111, 141, 211, 212, 241, 311, 312, 313 and 321
* 3 courses (300-level or above) from the minor will double count (BIOL 375, BIOL 4xx, and the course in botany. Biochemistry microbiology, physiology and zoology).
* 4 ICS courses (300-level or above)
* Bioinformatics focus area (3 courses)

**Minor in Biology**

* BIOL 172 (Introduction to biology II)
* BIOL 265 (Ecology and evolutionary biology)
* BIOL 275(Cell and molecular biology)
* BIOL 375 (Concepts of genetics)
* Minimum of 3 credits in: BIOL 401 (molecular biotechnology), 402(Principles of biochemistry), 405(Biochemistry), 406/406L (Cellular biology), 407/407L(Molecular biology), 409(Biology seminar), 441 (Basic biochemistry) or 499 (Biological problem).
* BIOL 171 (Introductory biology), CHEM161 (General chemistry I), 162 (General chemistry II), 272, (Organic chemistry I), and 273 (Organic chemistry II) if you take BIOL 402, 405, 406, 407 or 441.
* Minimum of 3 credits: approved upper level botany, biochemistry, microbiology, physiology and/or zoology.

### Focus area: Information Assurance and Computer Security

In response to emerging industry needs and student demand, the ICS faculty developed a focus area in Information Assurance and Computer Security. This curriculum was built through a team approach in June 2006 with the faculty of the ICS department and the Center for Information Assurance and Cybersecurity (CIAC) at the University of Washington. The director of the CIAC has taught a series of information assurance classes for the ICS department including: ICS425 Computer Security and Ethics, ICS426 Computer System Security and ICS491 Special Topics in Secure Development. Students who successfully complete this series earn a certificate from CIAC, a NSA/DHS Center of Academic Excellence in Information Assurance Education and Research. To date we have graduated over 75 students who have earned this credential.

The department also created a group called the “ICS Greyhats” that enables students to compete in regional and national collegiate cyberdefense competitions. In its first year, UHM students placed first in a virtual regional competition that included the University of Alaska Fairbanks and several colleges on the islands. Part of the student group’s mission is to reach out to local high schools that want to participate in similar exercises. The group has been enthusiastically embraced by our students, and also exposes local high school students to the opportunities available through the ICS department.

### Distance Learning

The ICS department is committed to expanding access to the University through distance learning. We have focused on Asynchronous Learning Network (ALN) media for learning. Asynchronous classes have no class meetings. Students learn the material “anytime, anywhere” by reading books, handouts, or Web pages and interacting with other students and the instructor via electronic media. Employing ALN enables us to provide educational offerings for the non-traditional student, the working professional and populations such as the military and neighbor island business people who cannot attend campus-based classes, whether due to scheduling conflicts such as job or childcare responsibilities, or because they are residents of neighbor islands or living outside of Hawai‘i.

In 1998, the Department received WASC approval for distance delivery of its bachelor and master programs. In 1999, while collaborating with the Outreach College, we secured a $405,000 grant from the Alfred P. Sloan Foundation to support this initiative. The UH Manoa Outreach College has marketed our online BA degree to students looking for non-traditional methods for completing their computer science degrees. The department is meeting our commitment to offer courses online by expanded ALN and hybrid course offerings each semester. Since the Department began offering online classes, we have steadily increased the number of students enrolling in ALN courses each academic year.

System Articulation

The ICS faculty have worked closely with their colleagues at the other system campuses to ensure articulation provides a clear path for students. All ten campuses of the University of Hawaii systems agreed to an ICS System Articulation Agreement in 2005 which remains in place. Given the access to distance education opportunities it is even more important articulation be clearly aligned and communicated to students.

Undergraduate Student Mentoring and Advising

Since 1998, the ICS department has employed an Educational Specialist to assist in all areas of student services, including recruitment, retention, placement, and outreach services. This position has allowed for consolidation of the Department’s record keeping system for all undergraduate students and helped to manage basic intake services. Hence, the role of faculty advising in our department has moved from bookkeeping activities to mentoring and project supervision activities. The Educational Specialist holds a master’s degree from ICS who is well qualified to mentor ICS students. Because of previous experience advising UH-Manoa students, the specialist’s advice is useful for ICS students who are seeking a BA degree. Students interested in ICS are first referred to the Educational Specialist who provides consistent advising as serves as the departments’ contact with the Arts and Sciences Advising office. Students are immediately counseled on the differences between the BA degree in Information and Computer Sciences and the BS degree in Computer Science in order to plan a degree program that meets their career goals. Through these meetings we found that some students need additional advising and are counseled appropriately.

The department began a program of mandatory student advising in 2009 for students who were: 1) entering UH Manoa for the first time; 2) transferring into the program from another college or university, or 3) changing their major to a bachelor’s degree to either the BS in Computer Science or the BA in Information and Computer Science. Advising is implemented through individual appointments and several hundred individual advising sessions have been conducted since January 1, 2009 to the present. We plan to continue conducting individual advising appointments and also conduct group sessions with individual follow-up advising.

# Assessment of student learning objectives

1. **Is the Program meeting its learning objectives for students**? (An assessment of the quality of student learning as indicated by systematic analysis of student performance with reference to standard expectations, surveys of student satisfaction with instructional aspects of the program, etc.)

**Academic Assessment Activities**

The curriculum of the ICS department is guided by the national standards set by the Association of Computing Machinery (ACM). ACM prepares recommendations for the curriculum of benchmark institutions for computer sciences. In the decades since the 1960’s ACM has worked to tailor curriculum recommendations to the rapidly changing landscape of computer technology (see <http://www.acm.org/education/curricula-recommendations>). The division also uses the ABET curriculum and standards as they are the recognized accreditor for the college and university programs in applied science, computing, engineering, and technology. As one of the most respected accrediting organizations in the U.S., ABET has provided leadership and quality assurance in higher education for over 75 years. ABET accredits over 3,100 programs at more than 600 colleges and universities worldwide. Each year, over 2,000 volunteers from 29 member societies contribute to ABET’s goals of leadership and quality assurance in applied science, computing, engineering, and technology education, serving as program evaluators, committee and council members, commissioners, and Board representatives.

The ABET Outcomes serve as a key standard in the development of the ICS curriculum and course syllabi. These outcomes include:

1. An ability to apply knowledge of computing and mathematics appropriate to the discipline.
2. An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.
3. An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.
4. An ability to function effectively on teams to accomplish a common goal.
5. An understanding of professional, ethical, legal, security and social issues and responsibilities
6. An ability to communicate effectively with a range of audiences.
7. An ability to analyze the local and global impact of computing on individuals, organizations, and society.
8. Recognition of the need for and an ability to engage in continuing professional development.
9. An ability to use current techniques, skills, and tools necessary for computing practice.

In a field like ICS, students must have access to the proper infrastructure in order to gain the hands-on learning needed through lab environments. Infrastructure such as lab space, hardware and software tools all play a role in delivering the academic curriculum as stated in the program and course learning outcomes. The ICS department has a unique governing structure that allows for curriculum and infrastructure to be an ongoing coordinated discussion item. As an overall academic planning agenda item, the ICS department has both a curriculum committee which considers all academic related recommendations to modifying existing courses and introducing new curricula. The department also has an Infrastructure Committee which recommends infrastructure expenditures based in part on assessment results. Throughout the year, these two committees meet monthly to examine the department relationship between the assessment plan to the program outcomes and the impact on infrastructure. These results are communicated to the departmental faculty each month and each semester the department holds a planning retreat to discuss overall recommendations.

**Student and Course Assessment**

The department uses both formative and summative evaluations for their courses. Faculty are regularly evaluated by the students. They have the choice of using the CAFE system or the ICS evaluation forms. The ICS department was one of the first departments to embrace and encourage the use of the online evaluation system. Student tests and examination results are used on a regular basis to measure the student outcomes and learning objectives with the actual student performance in the program courses.

Capstone course evaluation and course-embedded assessment are key in the evaluation of student learning. Regardless of the choice students make in completing their Bachelor of Arts degree, all are required to perform satisfactorily in a capstone experience such as:

* Students are assigned to work on a software engineering project with a team of peers. A key objective would be to evaluate the students’ ability to plan, design, implement, and test an original software projects. This also allows for the assessment of actual team work experience and the evaluation of issues that may arise during team / real-world work projects.
* Senior level programing projects may also be included in the capstone assessment. This would include a proposed “original” programming exercise to meet goals set between the student and faculty mentor. In this situation, the student is expected to completely document the process of the project, including end-user meetings and training sessions. A final oral presentation of the entire project usually serves and the culminating assessment.

Student surveys and exit interviews provide a different level of assessment. A project call TechHui includes an activity where students have the opportunity to share their experiences and interact with industry professionals. One specific example is an assignment in conjunction with TechHui which requires the students to list the top three great things about the ICS program and the top three not-so-great things about the ICS program. These comments allow the faculty and staff to evaluate candid comments of the students’ perceived experience. In general, the top three positive comments revolve around 1) the satisfaction of the software available for used in the ICS labs and software available as students, 2) the quality of faculty and advisors available for students and 3) the programs inclusion of industry related projects, networking and mentorship. The top three not-so-great comments revolve around: 1) the rigor and amount of time required to complete project work can be overwhelming, 2) the cost of text books for course work is high and 3) need to include more focus related course within the ICS requirements (e-focus, o-focus, wi-focus). These comments, both good and bad, help the faculty and related curriculum committees take into account areas the program can improve upon.

As part of the effort to monitor the educational quality of our program, the department began conducting a special skills assessment activity in the fall of 2001. The assessment results are fed back to the standing committees (curriculum and infrastructure) of the ICS department.

# Assessment of program resources

1. **Are program resources adequate (Analysis of number and distribution faculty, faculty areas of expertise, budget and sources of funds, and facilities and equipment)**

It is important to remember this proposal reflects all the resources available to the ICS department for the degrees the program offers, participates in with other programs and service related courses funded by the department (i.e. courses offered for the general student population). The Bachelor of Arts is only one of degree program that draws on these resources.

**Faculty Resources**

The ICS faculty is a diverse and well qualified group. The students clearly recognize the strength and the quality of faculty in the department. Of the student postings related to the top three great things of the program, high quality, well prepared, ethically response faculty tops the list. The list below illustrates the faculty, their rank and areas of expertise. This list clearly shows the diversity of research and academic strength within the faculty group.

#### Professors

M. Crosby, PhD (Chair)—human-computer interaction, augmented cognition, computer science education

D. Chin, PhD—artificial intelligence, natural language processing, cognitive science

P. Johnson, PhD (Associate Chair)—software engineering, artificial intelligence

D. Suthers, PhD—human-computer interaction, computer-supported collaborative learning, technology for education, socio-technical networks and online communities

#### Associate Professors

E. Biagioni, PhD—networks, systems, languages

K. Binsted, PhD—artificial intelligence, human-computer interaction, cognitive science, natural language processing

H. Casanova, PhD—high performance computing, distributed systems

G. Poisson, PhD—cognitive informatics, bioinformatics, machine learning

L. Quiroga, PhD (ICS/LIS)—information retrieval, databases, library systems, website design

N. Reed, PhD—artificial intelligence, autonomous agents

S. Robertson, PhD—human-computer interaction, digital government and digital democracy

J. Stelovsky, DrTechSc—computer-hypermedia, human-computer interaction

S. Still, PhD—bioinformatics/theoretical biology, information theory, machine learning

K. Sugihara, DrEng—algorithms, distributed computing, visual languages

#### Assistant Professors

K. Baek, PhD—computer vision, neural computation, machine learning

R. Gazan, PhD (ICS/LIS)—social aspects of information technology

C. Ikehara, PhD—biometrics and physiological sensors, adaptive human-computer interfaces

L. Lim, PhD—database systems

J. Patriarche, PhD—applications of computers to medicine

#### Assistant Specialists

G. Lau

M. Ogawa

#### Emeritus Professors

S. Itoga, PhD—database systems, expert systems, logic programming

D. Pager, PhD—compiler theory, theory of computability, artificial intelligence

Two of the faculty above, Dr. Gazan and Dr. Quiroga, hold dual appointments and are assigned half load to ICS and LIS. The Assistant Specialist’s hold other non-instructions duties. Their duties including academic support by coordinating and assisting the Department Chair and Graduate Program Chairs in major initiatives such as distance education and aspects of student services, including recruitment, financial assistance, and placement services. The specialists also coordinate outreach programs and act as liaisons with other campus-wide committees, alumni groups and the community. One specialist manages the several sections of ICS 101 with the help of several student assistants (including the training of the student assistants). The department employs 12 teaching assistants. Departmental research efforts have produced several grants which employ student research assistants.

The average instructional workload for each faculty member is two courses per semester. Using the Teaching Equivalent Workload Spreadsheet adopted by the College of Natural Sciences, we estimate that the faculty averages 8.82 semester credit hours for coursework (including directed reading courses, thesis advising and guest lecturing) and another 2.10 for additional teaching, for a total of 10.92 semester credit hours. On February 18, 2011 a comprehensive ICS Department Workload Documentation Procedure was approved by faculty. It is available for viewing at: <http://goo.gl/IGRrr>

In addition to teaching, all faculty are expected to participate with industry, agency and community groups. The list below illustrates only some of the collaborative activities being explored or carried out by the ICS faculty.

* The ICS department has discussed collaborative possibilities with the following IT companies: Alion Science, BAE, Booz Allen Hamilton, Camber, Central Intelligence Agency, DataHouse, Decision Research Corporation, FBI, High Technology Development Corporation, Hoana, Ikayzo, Infraguard, Orincon/Lockheed Martin, National Security Agency, Progeny Systems, Referentia, SAIC, TREK, and Oceanit. We are in the initiating a process for our students to intern with ITS at UH.
* Violet Harada and Dan Suthers were principal investigators of the Hawai‘i Networked Learning Communities (HNLC) Initiative, which is a partnership of the Hawai‘i Department of Education and the University of Hawai‘i to improve science, mathematics and technology learning in K-12 rural schools. It directly supports the effort to form a seamless connection between UH and the State DOE.
* We have had an internship program with the Hawai‘i Department of Health since 2002. Students are involved with the National Electronic Disease Surveillance System (NEDSS); an initiative that promotes the use of data and information system standards to advance the development of efficient, integrated, and interoperable surveillance systems at federal, state and local levels.
* Philip Johnson was a board member of the Hawai‘i Strategic Development Corporation (HSDC) which is a State agency created in 1990 to promote economic development and diversification in conjunction with private enterprise.
* ICS faculty members have collaborated with several members of the Maui High Performance Computing Center (MHPCC) are MHPCC is an Air Force Research Laboratory Center managed by the University of Hawai’i. Ranked as one of the top twenty supercomputer sites in the world, MHPCC provides world-class, parallel computing capability to the research, science, and warfighter communities.
* Luz Quiroga, Scott Robertson and Curtis Ikehara have students work on community projects

**Support Service Resources**

In addition to the instruction staff, the department has two information technology (IT) specialists. They are responsible or system administration, networking, installation, maintenance of the department’s computer hardware and software infrastructure. The IT specialists also researches software and other products in response to instructional and research nees and manages the purchasing and budget maintenance for the department.

The department also has an administrative and fiscal support person that works with the Department Chair to develop and track an annual department budget with corresponding projections for all sources of revenues including general and all extramural funds. Fiscal support is provided to assist faculty with budgetary matters related to grant and contract proposals for agencies such as NSF, DARPA, etc. Timely fiscal status reports are required to meet the needs of the college, department, accreditation bodies and researchers. Prompt and accurate payments of obligations to vendors upon delivery of goods and services is another function of the support staff, as well as work related to curriculum and instructional needs of the department.

**Student Support Services**

Often rated as one of the top three great things of the ICS program is the student advising provided by the department. The focused academic advising allows the faculty to have mentoring relationships with students. ICS students are also often the ones employed by the department as student assistants, teaching assistants and research assistants. These activities provide students not only the needed financial resources but also the real-world work experience. Through general funds and special funds, the department spends approximately $110,000 per year on student employment.

Examples of other financial support to students includes the recent $100,00 endowment for the cyber security program which will go directly to support students in the Bachelor of Arts program. The Fred and Annie Chin Scholarship provides BS students will a full scholarship each year. Many other scholarships and tuition waivers are provided to students on an annual basis. The department also supports high school students in the 6th through 12th grade by providing financial awards to winners of science fair competitions.

Internships and industry work experience is one of the major supports provided to students. It is well known by our participation in the National Survey of Student Engagement (NSSE) that students involved in industry and real-world related projects have higher rates of retention and success. The faculty of the ICS department are actively involved in creating relationships with industry partners to encourage student level positions and internship opportunities.

**Financial Program Resources**

The last major influx of general funds occurred in 2001 by the Hawaii state legislature which continues to remain in the ICS department’s line budget. This major investment into the program has allowed for the following: 1) hire instructors to expand our lower division course offerings, 2) increase the number of teaching assistants assigned to high enrollment classes, and 3) purchase equipment to support these individuals and the computer labs servicing the students. Overall, the funding allowed us to increase the number of sections of high-demand classes, improve the quality of education in each class, and reduce the drop out rate from its undergraduate programs. As a result, we have been able to improve the faculty-student ratio of our classes, provide additional course assistance, and provide additional computer laboratory facilities for student use. All in all, this has improved the student experience and increased the retention of students in the ICS program.

The computer science department receives an annual budget assigned by the College of Natural Sciences. This budget supports operational costs such as:

Software licensing fees Software purchase

Lab Teaching laboratory supplies Office supplies

Delivery charges, postage, freight Equipment maintenance, service agreements

Facilities repairs, maintenance, modifications Fees, subscriptions, dues

Printing and publications: program brochures Recruit Recruiting: travel, per diem

Telcom Installation, monthly fees, long distance

Travel for department business Lab Teaching laboratory equipment

Office equipment: computers, shredders Shop equipment: drills, cutters

Teaching Supplies and Equipment Instructors

Student help: office, graders

**Facilities and Equipment**

In this rapidly changing technology environment, ICS must constantly maintain and update its networking and data environment and provide up-to-date computer laboratory equipment for students and faculty at an estimated cost of $75,000 a year. The department has deployed a number of labs that focus on different learning environments. These include:

* Adaptive Multimodal Interaction (AMI) supports an environment using various metrics and methodologies to study user data. Typical experiments collect eye movements, pressure grasping, and other physiological input to develop novel and effective interactive systems. Research in this area has fostered new design principles, user interfaces, multimedia interaction systems, and visualizations of complex information
* Bioinformatics (BIL) supports Bioinformatics and Metagenomics projects.
* Collaborative Software Development Lab (CSDL) has pursued well-funded research leading to innovative software technologies in use by many academic and industrial sites worldwide.
* Concurrency Research Group (CORG) supports parallel and distributed computing, computer system simulation, and high-performance computing.
* Hawai’i Computer-Human Interaction (HI’ CHI)focuses on understanding how people use information systems and is dedicated to informing design based on human performance data. Current research on digital government applications and how people use the Internet to make political decisions.
* Laboratory for Interactive Learning Technologies (LILT) is forging partnerships with the Department of Education and other local educational agencies to support innovative uses of high technology in education.
* Machine Learning (ML) supports machine learning, robotics and computational neuroscience projects
* Research Center for Information Assurance (RCIA). This serves as a learning laboratory and test bed for investigations and applications related to the generation, organization, access, preservation, and secure use of digital information

The facilities occupied by the ICS Department primarily are located on the 3rd floor of the POST building. This includes office space for all the faculty and staff as well as a small conference meeting room. As noted in one of the top three not-so-good items of the student evaluation is the lack of “student space.” This is correct that there are a number of labs available but not necessarily readily available gathering space for students on the 3rd floor of POST.

# Assessment of program efficiency

1. **Is the program efficient? (An assessment of productivity and cost/benefit considerations with in the overall context of campus and University “mission” and planning priorities. Include quantitative measures comparing, for example, SSH/faculty, average class size, cost per SSH, cost per major with other programs in the college, on the campus and, as appropriate, similar programs to other UH campuses)**

In terms of program efficiency, the number of computer science majors and the number of student credit hours (SSH) from 2004-2010 can be found in Appendix 1. Line 26 (the net) of the academic program costs and revenue data sheet shows that the BA in ICS has made a profit every academic year (AY). The smallest amount earned was $710, 185 in the 2005-2006 AY and the largest gain of $1,480,588 was made in the 2009- 2010AY. The number of computer science majors nationwide has been in decline since 2004.

Figure 2 shows that the trend began to reverse in 2007 and the number of BA majors has been steadily increasing with the greatest number enrolling in 2010.

Figure 3 shows data from lines 44 and 45 of the academic program costs and revenue data sheet. The total instructional costs with fringe per SSH for the BA in ICS ranged from 36 in the2004-2005 AY to 92 in 2010-2011 AY. This compares with the College of Natural Sciences (NS) average of 316 in the 2004-2005 AY to 357 in 2010-2011 AY. The percentage of instructional cost of the ICS BA degree ranges from 11% to 25% of the NS college average. 17

** Figure 2. Number of BA majors in ICS**

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#### Figure 3. Comparison of ICS BA to NS Instruction Costs per SSH

The number of students in the ICS BA program has grown from 31 in the Fall1999 semester, to close to 78 in the Fall 2010 semester. The percent of ICS majors choosing the BA degree is steadily increasing and has more than doubled since the Fall1999 semester. As shown in Figure 4, the proportion of BA undergraduates in ICS has increased from 6% to 33%.

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#### Figure 4. Percent of Enrollment of ICS BA Students

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#### Figure 5. Graduation rates of ICS BA Students

With the addition of the BA degree and the popularity of technology degrees, retention and graduation rates have steadily improved. The number of students to graduate with a BA degree has remained relatively constant with an average of 12 out of 56 graduates each fall semester. Figure 5 shows the percentage of BA graduates has changed from an initial 27% of the total ICS graduates in the Fall 1999 semester to 39.5% of the ICS graduates in the Fall2010 semester.

# Assessment of program quality

5. Evidence of program quality.

**(A qualitative assessment of the program in relation to competing demands for resources by new programs and continuing programs. Accreditation or other external evaluation, student performance [e.g., on external exams], satisfaction, placement and employer satisfaction, awards to faculty and students faculty publication record, evaluation of faculty…)**

The ICS department has national and international reputation and the faculty have a number of accomplishments, including grants, fellowships, awards, contracts and commissions. They have productive research records and are involved in developing information enterprises, hold technological patents and have engaged with the community in several ways. Efforts have been made to generate external funding as attested by a list of several Labs pursuing well-funded research leading to innovative software technologies; others receiving industrial support providing students with opportunities to work with state-of-the-art networking technologies or still others forging partnerships with the Department of Education and other local educational agencies.

Encouraged by the provisional approval of a BA in Information and Computer Sciences, the approval of a Minor in Computer Science and WASC approval for distance delivery of its bachelor and master programs, we have introduced major curricular changes and articulation agreements with UH-Hilo, Maui College and the Community Colleges for most of our 100 and 200 level courses.

There has been considerable discussion regarding the need to provide increased access to “information technology” (IT), “computer science”, “programming” and other related general concepts. “The First Two” Project attempted to meet this need. Using funds from the state government we established a learning and support environment to directly impact the first two years of course work in ICS. This includes ICS 111 and 211 (Introduction to Computer Science I & **II),** ICS 212 (Program Structure), ICS 141 & 241 (Discrete Mathematics I & II), and ICS 311 (Data Structures & Algorithms). Although the changes in these foundational ICS courses are incremental, there is a long term effort to revamp the upper division undergraduate courses to reflect the latest changes in the Association for Computing Machinery (ACM) 2008 computer science curriculum. The ultimate goal is to provide an environment or cocoon of support for those students enrolled 20

in ICS 111, ICS 211, ICS 212, ICS 141, ICS 241, and ICS 311. These courses represent the basic concepts and skills that frame computer science and “informatics”. They also provide opportunities for application of technology to other fields. The program will not differentiate between students in regular day, extended, summer, or ALN courses.

We have also been exploring different teaching methodologies that use active learning techniques. In 2007, we began testing how using a studio-based learning (SBL) methodology could improve learning outcomes in computer courses. This project was initially funded with a grant from NSF and was to addresses the dual challenge of retaining computer science students, and broadening access to computing education, by building a community of educators and researchers who will apply, and empirically validate, a novel studio-based instructional model in introductory computing education courses. Adopted from architectural education, this instructional model emphasizes learning activities in which students (a) construct personally-meaningful representations of the algorithms and programming concepts under study, and then (b) present those representations to their instructors and peers for feedback and discussion within the context of so-called “design crits.” This project brings together researchers and educators at the local and national levels in order to build a community committed to refining, adapting, applying, and studying studio-based approaches in computing education. We have sought input from a national audience, with the ultimate aim of planning a future project to implement the approach in computing education courses on a regional or national level. As a part of this initiative, from 2007 to the present, we employed SBL methodology in ICS 101, 110, 111, ICS 211, ICS 212, ICS 141, and ICS 311. We compared sections of these courses taught in the traditional format with courses taught using the SBL or studio format.

We have also teamed with George Washington University on Project PISCES (Partnership in Securing Cyberspace through Education and Service). This program provides opportunities for students with diverse backgrounds to become Computer Security and Information Assurance (CSIA) professionals and help protect the safety and security of our nation’s information infrastructure. It does this by combining scholarships, university courses in computer security and information assurance, internships, laboratories, and government service, and appropriate monitoring and evaluation for these students. A major new thrust of the project is to include students from the ICS department at the University of Hawaii at Manoa (UHM) to provide potential successful CSIA applicants.

Recently we have begun a series of initiatives to improve and award student quality. Table 3 shows some of our recent activities.

#### Table 3. Improving Student Quality

|  |  |  |
| --- | --- | --- |
|  | **Impacting: Incoming, Undergrad & Grad** | **Project Description** |
| 1 | Incoming | ICS Science Fair Awards - Five $200 awards for computer science project. One for the best project from each class level from 8th grade, freshman, sophomore, junior and senior. Status: On going from 2009. |
| 2 | Incoming | Fred and Annie Chan Scholarship for incoming Freshmen. First, this requires organizing a publicity campaign to students, counselors and parents. Second, collection and organizations of applicants. Third, the assembly of a selection committee. Finally, the implementation and follow-up with the recipient.  Status: On going from 2008. |
| 3 | Incoming | ICS Minor promotion – This is a promotion to recruit more undergraduates to minor in ICS requires the printing and disbursement of over 500 flyers on the ICS minor program. Status: Ongoing from 2007. |
| 4 | Undergrad | ICS 290 - Computer Science Careers: An exploration of the specialties of computer science – Spring 2009. A class designed to provide students with information to help define and achieve their goals in computer science. Status: Ongoing from 2010. |
| 5 | Undergrad & Grad | W. Wesley and Hiromi Peterson Scholarship – To encourage research and scholarship among students. Status: Will start once funds become available. |
| 6 | Incoming, Undergrad & Grad | Bachelor’s packet, thanking graduates for selecting our department, informing of alumni services and requesting they send thank you notes to their high school mentors. The thank you notes increases awareness of the ICS program and will hopefully motivate more high school mentors to send their best students to our department. Status: Ongoing since 2008. |
| 7 | Undergrad | Promotion to encourage high end undergraduates to take a few graduate courses before graduating. This will provide high end students with transcript that stands out and confidence in their academic ability. This requires organizing a publicity campaign to students. Status: Ongoing since Fall 2009. |
| 8 | Undergrad & Grad | ICS Software Engineering Competition for undergraduate student where graduate student may mentor undergraduates. First, this requires coordinating with the faculty on the notification and incentive systems to increase student participation. Second, conducting the competition and awarding of the winners. Status: Competition held Fall 2009. |
| 9 | Undergrad | Promoting the hiring of lower division CS students by commercial CS organizations as entry level help. This will provide students who cannot do CS work with the experience of working in a CS environment. Status: Started 2011. |
| 10 | Undergraduate & Graduate | Graduation and awards ceremony.  Status: Spring 2011 graduates completed |
| 11 | Undergraduate & Graduate | Short Skill Set Classes - Creating special non-credit classes to fill-out the specific skill sets requested by the local computer companies. Status: Organizing in progress – currently communicating with local companies. |
| 12 | Undergraduate | GRE Award – This award is to encourage high performing undergraduate computer science majors to prepare for graduate school. A full-time undergraduate ICS student who takes the Graduate Record Exam (GRE) and scores above the 80% percentile for two categories can apply for a $200 award. A student can only receive this award once. Status: Organizing in progress. |
| 13 | Undergraduate | Help promote the department of Information and Computer Sciences at the university open house, high school counselors meeting, and high school events. Since 2007. |
| 14 | Undergrad & Grad | ICS 40th Alumni Lunch with alumni, faculty and their best students. Status: Completed 2008 |

Successful Hawai’i-based entrepreneurial ventures provide evidence that the employment of graduates in relationship to objectives are being met. A large number of local and mainland companies that have recently recruited our graduates attest to the success of our academic programs and are shown in Table 4. Federal agencies like the FBI and CIA have also shown a strong interest in our majors.

###### Company Title

|  |  |
| --- | --- |
| 21st Century Systems | Software Engineer |
| aDiJasTechnology Consulting | President |
| ADTECH | Consultant |
| Aloha Island Inc. | |
| Amazon | Software Scientist |
| Arcadia | IT Support Specialist |
| Boeing | Software Scientist |
| Booze-Allen-Hamilton | |
| CampusDocs | Software Engineer |
| Center on the Family /UHM | |
| DataHouse | Software Development |
| Decision Research Corporation | Applications Developer |
| Digital Mediums | |
| eBase Solutions, Inc | |
| Eckerd College | Associate Professor |
| Electron Management Support & Services | |
| Guide.Net | Software Scientist |
| HECO | ITS Development Specialist |
| IBM | Software Scientist |
| IGN | Director |
| Institute of HPC | Principle Investigator |
| Kapiolani Community College | IT Specialist PBA |
| Kofax | Senior software Engineer |
| Konami Entertainment | |
| Lockheed Martin | System Engineer |
| Microsoft | Development Lead |
| Microsoft/Volt | |
| Motorola | Build, Release Engineer |

# Assessment of program objectives

7. Are program objectives still appropriate functions of the college and University?(Relationship to University mission and development plans, E5.201 P 13 of 13 evidence of continuing need for the program, projections of employment opportunities for graduates, etc.)

The following section addresses how the mission statements for the Department of Information and Computer Sciences support the larger missions of the University of Hawaii at Manoa, the University of Hawaii system, the state of Hawaii, and the overall national picture.

The mission of the Department of Information and Computer Sciences is to nurture a world-class community of students and faculty dedicated to innovative scientific and information-related research and education for the benefit of the participants, Hawaii, the United States, and the world. A goal of the ICS program is to prepare students to be research and development leaders in computer science and computer technology. To this end, the program is a catalyst and a resource for shaping the future of the broad discipline of computer science. The faculty embraces the mutual interdependence of research and teaching to achieve excellence in both. As part of its mission the program brings the latest research findings into courses and actively involves students in research endeavors of the faculty. The program also provides leadership in the application of high technology to improve the educational experience.

The University of Hawaii System strategic plan1approved by the board of regents in June 2002 has the following goals for the system:

1 <http://www.hawaii.edu/ovppp/stratplan/UHstratplan.pdf>

2 <http://www.neilabercrombie.com/index.php/technology>

* Educational Effectiveness and Student Success
* A Learning, Research, and Service Network
* A Model Local, Regional, and Global University
* Investment in Faculty, Staff, Students, and Their Environment
* Resources and Stewardship

The ICS department’s mission statement closely aligns with the first goal of educational effectiveness and student success since this is covered in both parts of the department’s mission. Furthermore, the department helps to provide the university system with a strong learning, research, and service network.

#### State of Hawaii

At the state level, Governor Neil Abercrombie’s Technology and Information platform states the need for human capital and education in the area of technology, specifically:

*“The fuel of an innovation economy is our human capacity to learn and create. Everyone can contribute. Education at all levels is the fundamental investment we will make to improve our economy. Industry and public education must work very closely to support each other and ensure highly skilled employees are being prepared at the same rate that high skill jobs are being created.”2*

The need for education in technical fields is further underscored by Office of Department of Business, Economic Development and Tourism’s report on Hawaii’s Technology

|  |  |  |  |
| --- | --- | --- | --- |
| **Fastest Growing Jobs** | **Employment change** |  |  |
| Occupation | 2000-2010 |  |  |
|  | Number (thousands) | Percent Increase | Most significant source of education or training |
| Computer software engineers, applications | 380 | 100 | Bachelor’s degree |
| Computer support specialists | 490 | 97 | Associate degree |
| Computer software engineers, systems software | 284 | 90 | Bachelor’s degree |
| Network and computer systems administrators | 187 | 82 | Bachelor’s degree |
| Network systems and data communications analysts | 92 | 77 | Bachelor’s degree |
| Desktop publishers | 25 | 67 | Postsecondary vocational award |
| Database administrators | 70 | 66 | Bachelor’s degree |
| Personal and home care aides | 258 | 62 | Short-term on-the-job training |
| Computer systems analysts | 258 | 60 | Bachelor’s degree |
| Medical assistants | 187 | 57 | Moderate-term on-the-job training |
| Social and human service assistants | 147 | 54 | Moderate-term on-the-job training |
| Physician assistants | 31 | 53 | Bachelor’s degree |
| Medical records and health information technicians | 66 | 49 | Moderate-term on-the-job training |
| Computer and information systems managers | 150 | 48 | Bachelor’s degree, plus work experience |
| Home health aides | 291 | 47 | Short-term on-the-job training |
| Physical therapist aides | 17 | 46 | Short-term on-the-job training |
| Occupational therapist aides | 4 | 45 | Short-term on-the-job training |
| Physical therapist assistants | 20 | 45 | Associate degree |
| Audiologists | 6 | 45 | Master’s degree |
| Fitness trainers and aerobics instructors | 64 | 40 | Postsecondary vocational award |
| Computer and information scientists, research | 11 | 40 | Doctoral degree |

(Source: <http://www.bls.gov/news.release/ooh.t01.htm> Accessed Oct 2002)

Our degree programs directly address the highlighted occupations. Focusing on just these occupations, the Bureau is projecting an increase of more than 50% that would result in over 1.4 million new positions.

In a U.S. Department of Commerce, Office of Technology Policy report entitled “The Digital Workforce: Building Infotech Skills at the Speed of Innovation” (June 1999) Alan Greenspan said, “The rapid acceleration of computer and telecommunications technologies is a major reason for the appreciable increase in our productivity in this expansion, and is likely to continue to be a significant force in expanding standards of living into the twenty-first century.” This bodes well for the increasing use of information technology and for the strategic role that the ICS Department might play in delivering high-quality teaching and research at UHM.

Recently there has been a downturn in the job market because of the “dot-bomb” crash of internet companies. An article in USA Today (available at: <http://www.usatoday.com/tech/news/2002-10-08-computer-science-majors_x.htm>) states: “Computer science graduates are likely to be plentiful for several years, as current students finish degrees. Problems could arise when this freshman class graduates.” Providing a counterview, Verna Schuetz of Virginia Tech’s computer science department predicts that, “in four or five years, we’ll see a shortage.” The Department concurs with Scheutz that there will be a continued long term national need for our graduates even though there is a current decline in job opportunities.

#### International needs

The globalization of society makes this need the same as that for the national needs. The central role of information technology in almost all aspects of higher education is expected to increase dramatically for the foreseeable future. Areas such as bioinformatics, medical informatics, business informatics, and educational informatics argue for the increasing need for our interdisciplinary BA program.

# Appendix A: ICS Course Descriptions

**ICS 111 Introduction to Computer Science I (4)** Overview of computer science, writing programs.

**ICS 141 Discrete Mathematics for Computer Science I (3)** Logic, sets, functions, matrices, algo­rithmic concepts, mathematical reasoning, recursion, counting techniques, probability theory.

**ICS 211 Introduction to Computer Science II (3)** Algorithms and their complexity, introduction to software engineering, data structures, searching and sorting algorithms, numerical errors.

**ICS 212 Program Structure (3)** Program organization paradigms, programming environments, implementation of a module from specifications, the C and C++ programming languages.

**ICS 215 Introduction to Scripting (3)** Introduction to scripting languages for the integration of applications and systems. Scripting in operating systems, web pages, server-side application integration, regular expressions, event handling, input validation, selection, repetition, parameter passing, Perl, JavaS­cript, and PHP.

**ICS 241 Discrete Mathematics for Computer Science II (3)** Program correctness, recurrence relations and their solutions, divide and conquer relations, relations and their properties, graph theory, trees and their applications, Boolean algebra, introduction to formal languages and automata theory.

ICS 290 Computer Science Careers: An Exploration of the Specialties of Computer Science (1) Exploration of the specialties of computer science.

**ICS 311 Algorithms (3)** Design and correctness of algorithms, including divide-and-conquer, greedy and dynamic programming methods. Complexity analyses using recurrence relations, probabilistic methods, and NP-completeness. Applications to or­der statistics, disjoint sets, B-trees and balanced trees, graphs, network flows, and string matching.

**ICS 312 Machine-Level and Systems Programming (3)** Machine organization, machine instructions, addressing modes, assembler language, subroutine linkage, linking to higher-level languages, interface to operating systems, introduction to assemblers, loaders and compilers.

**ICS 313 Programming Language Theory (3)** Syntax, semantics, control structures, variable binding and scopes, data and control abstractions. Programming in functional (LISP) and logic (Prolog) programming styles.

**ICS 314 Software Engineering I (3)** System specification, modeling and analysis, prototyping, hierarchal design, program design methods, cost estimation, project management, computer-aided software design. Team-oriented software-design project.

**ICS 315 Web Design and Management (3)** Web design principles, XML and HTML, tables, forms, and frames, multimedia objects, security, script­ing for web applications, web servers, commercial aspects, new technology.

**ICS 321 Data Storage and Retrieval (3)** Data storage devices, timing and capacity, programming for files, hashed and indexed files, introduction to relational database systems.

**ICS 331 Logic Design and Microprocessors (4)** (1 3-hr Lab) Basic machine architecture, microprocessors, bus organization, circuit elements, logic circuit analysis and design, microcomputer system design.

**ICS 332 Operating Systems (3)** Operating system concepts and structure, processes and threads, CPU scheduling, memory management, scheduling, file systems, inter-process communication, virtualization, popular operating systems.

**ICS 351 Network Design and Management (3)** Overview of the internet and its capabilities; introduction to HTTP, TCP/IP, ethernet, and wireless 802.11; routers, switches, and NAT; network and wireless security; practical experience in designing and implementing networks.

**ICS 361 Introduction to Artificial Programming (3)** Introduction to the theory of Artificial Intel­ligence and the practical application of AI techniques in Functional (Common LISP and/or Scheme) and Logic (Prolog) programming languages. Students gain practical experience through programming as­signments and projects.

**ICS 390 Computing Ethics for Lab Assistants (3)** A lecture/discussion/internship on ethical issues and instructional techniques for students assisting a labo­ratory section of ICS 101. The class uses multiple significant writing and oral presentation activities to help students learn course content.

**ICS 414 Software Engineering II (3)** Continuation of 413. Project management, quality, and productiv­ity control, testing and validation, team manage­ment. Team-oriented software-implementation project. Pre: 413.

**ICS 415 Introduction to Programming for the Web (3)** Introduction to emerging technologies for construction of World Wide Web (WWW)- based software. Covers programming and scripting languages used for the creation of WWW sites and client-server programming. Students will complete a medium-sized software project that uses languages and concepts discussed in class.

**ICS 419 The Science, Psychology and Philosophy of Systems Design (3)** Scientific, psychological and philosophical bases of systems design, including a survey of human-factors and ergonomic standards; the nature of innovation and creativity as it relates to systems design. Web-enhanced course.

**ICS 421 Database Systems (3)** Principles of database systems, data modeling, relational models, database design, query languages, query optimiza­tion, concurrency control data security.

**ICS 423 Computer Security (3)** Legal, ethical and technology issues in computer access, confidentiality, authentication, privacy and intellectual property.

**ICS 424 Application Frameworks (3)** Experience producing applications with at least two different applications frameworks. A-F only.

**ICS 425 Computer Security and Ethics (3)** Theoretical results, security policy, encryption, key management, digital signatures, certificates, pass­words. Ethics: privacy, computer crime, professional ethics. Effects of the computer revolution on society.

**ICS 426 Computer System Security (3)** Informa­tion flow, confinement, information assurance, malicious programs, vulnerability analysis, network security, writing secure programs.

**ICS 431 Computer Architecture (3)** Memory management, control flow, interrupt mechanisms, multiprocessor systems, special-purpose devices.

**ICS 432 Concurrent and High-Performance Programming (3)** Principles of concurrent and high performance programming. Multi-threading in C and Java for shared-memory programming. Distrib­uted memory programming with Java. Introduction to cluster computing.

**ICS 435 Machine Learning Fundamentals (3)** Introduction to machine learning concepts with a focus on relevant ideas from computational neurosci­ence. Information processing and learning in the nervous system. Neural networks. Supervised and unsupervised learning. Basics of statistical learning theory.

**ICS 441 Theory of Computation (3)** Grammars, sequential machines, equivalence, minimalization, analysis and synthesis, regular expressions, comput­ability, unsolvability, Gödel’s theorem, Turing machines.

**ICS 451 Data Networks (3)** Network analysis, architecture, digital signal analysis and design; circuit switching, packet switching, packet broadcasting; protocols and standards; local area networks; satellite networks; ALOHA channels; examples.

**ICS 452 Software Design for Robotics (3)** Sensors, actuators, signal processing, paradigms of robotic software design, introduction to machine learning, introduction to computer vision, and robot-to-human interaction. A-F only. Pre: two ICS 300-level courses or consent.

**ICS 461 Artificial Intelligence (3)** Survey of artificial intelligence: natural language processing, vision and robotics, expert systems. Emphasis on fundamental concepts: search, planning, and problem solving, logic, knowledge representation.

**ICS 464 Human Computer Interaction I (3)** Application of concepts and methodologies of human factors, psychology and software engineering to ad­dress ergonomic, cognitive, and social factors in the design and evaluation of human-computer systems.

**ICS 465 Introduction to Hypermedia (3)** Basic issues of interactive access to information in various formats on computers. Available hardware and soft­ware: editing, integration, programming. Implementation of a sample information system.

**ICS 466 Design for Mobile Devices (3)** Lecture introducing design issues, programming languages, operating systems and mark-up languages for internet-enabled mobile devices, such as cell phones and PDAs.

**ICS 469 Cognitive Science (3)** Introduces basic concepts, central problems, and methods from cogni­tive science. Identifies contributions from disciplines such as cognitive psychology, linguistics, artificial intelligence, philosophy, and neuroscience.

**ICS 475 Introduction to Bioinformatics Sequences and Genomes Analysis (3)** Introduction to bioinformatics to computer sciences students by focusing on how computer sciences techniques can be used for the storage, analysis, prediction and simulation of biological sequences (DNA, RNA and proteins).

**ICS 476 Bioinformatics Algorithms and Tool Development (3)** Study of commonly used bioinformatics’ algorithms, with an emphasis on string, tree, and graph algorithms. Presentation of probabilistic and clustering methods. Implementation of the studied algorithms and design of applications.

**ICS 481 Introduction to Computer Graphics (3)** Fundamentals of computer graphics including graphics hardware, representation, manipulation, and display of two- and three-dimensional objects, use of commercial software.

**ICS 483 Computer Vision (3)** Introductory course in computer vision. Topics include image forma­tion, image processing and filtering, edge detection, texture analysis and synthesis, binocular stereo, segmentation, tracking, object recognition and applications.

# Appendix B: B.A. in ICS Schedule

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | | | | |
| ***Fall 1*** | **Cr** | **N** | ***Spring 1*** | **Cr** | **N** |
| **ICS 111** | 4 |  | **ICS 211** | 3 | 3 |
| **ICS 141** (FS) | 3 |  | **ICS 241** (FS) | 3 | 3 |
| FW | 3 |  | FG-B (or A or C) | 3 |  |
| FG-A (or B or C) | 3 |  | HSL 101 | 3 |  |
|  | ***13*** | ***0*** |  | ***12*** | ***6*** |
| ***Fall 2*** |  |  | ***Spring 2*** |  |  |
| **ICS 311** | 3 | 3 | **ICS 321** | 3 | 3 |
| **ICS 212** | 3 | 3 | **ICS 312 or 331** | 3 | 3 |
| HSL 102 | 3 |  | HSL 201 | 3 | 3 |
| DA (or DH or DL) | 3 |  | DS | 3 |  |
| Elective | 3 |  | Elective | 3 |  |
|  | ***15*** | ***6*** |  | ***15*** | ***9*** |
| ***Fall 3*** |  |  | ***Spring 3*** |  |  |
| **ICS 313 or 361** | 3 | 3 | **ICS 400-level Elective** | 3 | 3 |
| **ICS 400-level Elective** | 3 | 3 | **\* 300+ (area of concentration)** | 3 | 3 |
| HSL 202 | 3 | 3 | DB | 3 |  |
| DH (or DA or DL) | 3 |  | DP | 3 |  |
| DS | 3 |  | DY | 1 |  |
| Elective | 3 |  | Elective | 3 |  |
|  | ***18*** | ***9*** |  | ***16*** | ***6*** |
| ***Fall 4*** |  |  | ***Spring 4*** |  |  |
| **ICS 400-level Elective** | 3 | 3 | **ICS 400-level Elective** | 3 | 3 |
| **\* 300+ (area of concentration)** | 3 | 3 | **\* 300+ (area of concentration)** | 3 | 3 |
| **\* 300+ (area of concentration)** | 3 | 3 | Non-Introductory Elective | 3 | 3 |
| Non-Introductory Elective | 3 | 3 | Non-Introductory Elective | 3 | 3 |
| Elective | 3 |  | Elective | 3 |  |
| Elective | 3 |  | Elective | ***3*** |  |
|  | ***18*** | ***12*** |  | ***18*** | ***12*** |
|  |  |  | **Cr** = credit hours for course(s); **A** = A&S credits;  **N** = non-introductory A&S credits | | |
| ***Total credits after 8 semesters*** | ***125*** | ***60*** |
| Major requirements for the B.A. in Computer Science are noted in **bold.** | | | | | |
| \*Assumes that you pick an A&S course to satisfy your area of concentration requirement. | | | | | |
| **This sample four-year plan must be used in conjunction with your** *Arts & Sciences College Program Requirements* **sheet as all requirements for a B.A. degree (e.g., focus requirements, breadth/depth) are not included.** Students may be able to double-dip some requirements. | | | | | |
| Actual credit counts vary depending on registration. Check with your advisor as course numbers/credits/prerequisites may change. | | | | | |