CS491
Great Principles of Information Technology

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Approved by CS Faculty 10/25/00
as senior option course

DRAFT revision as GenEd Synthesis Course 6/12/02

This is a revision of the course proposal for the existing course CS491 to meet the synthesis requirements for General Education. The course was originally designed with this in mind, but at the time of its approval the current guidelines for synthesis courses were not developed.

I. CATALOG DESCRIPTION

A. **CS 491:** Great Principles of Information Technology (3:3:0)

B. **Prerequisite:** senior standing (at least 90 credit hours) including two 400-level CS courses; completion or concurrent enrollment in all other required general education courses.

C. **Catalog Description:** A synthesis course for CS majors. Offers a holistic view of the field and its connections with other fields in science, business, philosophy, and public policy. Covers great principles of information technology from algorithms and programming, distributed systems, and cooperative systems. Emphasizes the historical development of these principles, why they have stood the tests of time, how they relate to one another, and how they relate to issues in other fields. Also covers major contemporary open questions affecting information technology. Includes a project with an oral presentation before a faculty panel.

D. **Senior Option Course:** this course is listed as one of the 400-level courses on the option list for seniors. Students can choose any four of the eight (formerly seven) courses on that list.

E. **General Education Synthesis Course.** This course satisfies the synthesis requirement of General Education. Information Technology pervades and touches all sciences, economic sectors, business, government, work, leisure, and personal life. This course will engage students to understand the impacts of IT in other sciences, mathematics, business, profession, and public policy. It draws upon the General Education foundations in written communication, oral communication, quantitative reasoning, and IT. It connects strongly with the General Education core areas of natural sciences, history, western civilization, and global understanding. The vehicle for making these connections is the "great principle". A principle of IT cannot be considered "great" unless it has demonstrated historical impact in many areas, is part of wide practice, and has stood the test of time. Students will discuss and write about each of the topics in the syllabus from this perspective. In addition, they will complete a project with written report and oral presentation before a faculty panel.

II. JUSTIFICATION

A. Course Objectives:

This course aims to develop students' sense of the whole of information technology and its relation to the world by synthesizing and integrating their existing knowledge from separate CS specialties. It discusses the great principles on which CS is founded, their relationships with one another, and their relationships with other fields. The other fields include other science fields, business, philosophy, and public policy. The course examines what makes a principle great -- durable, wide, and lasting impact -- and traces the history of each selected principle to demonstrate why it is great. It also examines several of the major system problems facing information technologies today, speculating about how the great principles will influence the development of solutions and what new principles might emerge from the development.

B. Desirability of This Course:

The CS faculty have been interested for some time in a synthesis course for CS majors. In 1996 the faculty approved CS 490, a team-project course in which students would design a system that integrates their knowledge from other courses. The faculty offered CS490 as an option for seniors (on the list to select 4 of 7 400-level courses). Student interest in CS490 has been very disappointing. Enrollment has been insufficient every semester since its inception to justify teaching it. The factors contributing to this include: projects in many other CS courses, many students being employed already, and a hot job market in which prior project experience is not essential.

In 1998, P. J. Denning experimented with a CS499 with a different approach to integrating students' knowledge: a study of the core principles of computing systems. Student response was strongly positive. Denning offered the course a second time in 1999 and made

further improvements; the students rated the course at 4.9.
A team of IT&E faculty, led by Denning to produce a model curriculum for the new IT College at the University of United Arab Emirates, liked this approach so well that they recommended it as a capstone course in the CS major of the model curriculum.

C. Relationship to Other Undergraduate Courses:

This course will help students integrate the knowledge of computing and information technology that they have learned from their separate courses. It will also help them establish relations between the scientific topics and concerns in other science fields, business, philosophy, and public policy. It is intended for students with senior standing (90 credit hours completed toward the major) who have completed at least two 400-level courses and their other Gen Ed requirements.

CS491 is a senior option: CS majors select 4 courses from the option list, which now includes CS491.

This course can also be offered to IT seniors from CE and SE programs with equivalent standing toward their majors. Instructor permission would be needed to assure that these students have adequate prior contact with the issues covered.

D. Potential Instructors

The course is amenable to team teaching. One faculty member would be the course coordinator and other faculty would come lead individual sessions in their areas of specialization. The coordinator could also invite outside experts to give guest presentations. With this approach, the need for one person to know everything in the syllabus is reduced, thereby broadening the pool of potential instructors.

Several faculty have already said they would be interested to teach (or coordinate the section of) this course: Peter Denning, Ken DeJong, Daniel Menascé, and David Rine.

E. Logistics of Student Presentations

The course sections would be limited to 30 students each. Each section would be organized into student teams (nominal size 3) working on projects with a final oral presentation to a panel of at least two faculty. It is easy to do this without increasing the workload of the course. In a class of size 30, there would be 10 team presentations rather then 30 individual presentations. An appropriate amount of time would be built into the schedule to allow for this.

III. PLANNED OFFERING:

One section every year beginning Fall 2001. Additional sections as needed to meet student demand.

IV. SYLLABUS

A. CS 491: Great Principles of Information Technology (3:3:0)

B. Topics covered:

NOTE: the selection of topics within each category listed below will vary according to the expertise of the participating faculty or guest lecturers. This framework will encourage and accommodate differing perspectives of the participating faculty.

1. What makes ideas great (1 week)

An examination of few great ideas from science and technology to illustrate the pattern of a great principle: (1) It solves an important problem that vexed many people. (2) The problem solved by the principle is inherent in the way people conduct their lives and businesses, and thus the principle has been reinvented by different groups as they encounter the problem. (3) The impact of the principle was wide and deep and changed the practice of science, industry, or society.

2. Algorithmics (2 weeks)

An examination of great principles applying to all forms of computation. These principles address what machines (controlled by algorithms) can and cannot do and what we must do to circumvent inherent computational complexity. It also addresses misconceptions that many people in other fields have about algorithms and programming, and in particular the limitations of the metaphor of information. Suggested topics:

- What Machines Can and Cannot Do
- Programs = Algorithms + Data
- Complexity: measuring algorithmic time and space
- Circumventing the complexity barrier with heuristics and evolutionarics
- Universal machines
- Self reproduction and artificial life
- Language and Limitations of Information

3. Distributed Systems (5 weeks)

An examination of great principles for designing reliable and dependable systems of clients and servers embedded in networks. Suggested topics:

Importance of reliable, dependable systems in many sectors of science, business, and government.
The Internet (survivable, packet switched, dynamically routed, protocols, WWW)
Naming (objects in large systems)
Secret and Secure communication
Virtualization (memory, machines, other simulations)
Concurrent programming (processes, semaphores, deadlocks, synchronization)
Transactions and data (atomic, two-phase commit, serializability, e-commerce)
Human Computer Interface (GUI, shell, translators, parsers)
Laws of system performance (performance modeling)

4. Cooperative Systems (3 weeks)

An examination of principles for systems that interact strongly with humans, help them coordination actions, and support their businesses and enterprises. These are the aspects encountered most frequently by users of IT systems in science, business, and government. Suggested topics:

Workflow models and systems
Information systems
Agent-based computing
Speech recognition and understanding
Perception
Machine learning
Enterprise and E-Commerce

5. Contemporary Open Questions (2 weeks)

An examination of major contemporary open questions around which there is consensus of a big need for a solution but lack of consensus (and even controversy) about the nature of a solution. These questions are coming from other fields and are affecting the design of IT systems. Examples from the current day:

Nomadic computing
Interaction models ("after the desktop")
Alternative methods of computing ("after Moore's law for silicon")
Oxygen architecture (MIT paradigm of design)
Bionic body parts
Will intelligent machines displace humans?
Resisting dehumanization by technology

C. Books

David Abram. *The Spell of the Sensuous.* Vintage. 1997.
Richard Feynman. *Lectures in Computing*. Perseus. 1996.
Alan Biermann. *Great Ideas in Computer Science*. MIT Press, 1990.
James Burke. *The Day the Universe Changed*. Little Brown. 1995.
Hubert Dreyfus. *On The Internet.* Routledge. 2001.
Danny Hillis. *The Pattern on the Stone*. Perseus. 1999.
Robert Hazen and James Trefil. *Science Matters*. Anchor. 1991
David Harel. *Computers, Ltd.* Oxford. 2001.
John Seely Brown and Paul Duguid. *The Social Life of Information.* Harvard Business. 2000.
James Trefil, Robert Hazen, Anthony Gaudin. *The Sciences: An Integrated Approach*. Wiley. 1999.

D. Suggested Grading Approach

Breadth requirement (60%, individual effort): students understand at least six of the great principles well; they demonstrate their understanding by providing written solutions to a set of Great Design Problems handed out at the beginning of the semester. Class time will be devoted regularly to answering questions about these design problems.

Depth requirement (40%, team effort): student teams complete a project of researching a great principle to document its history, its recurrences, its impact in other fields, and its durability. The project aims to assure that students have learned to be the kind of observer outlined in the first lecture. All students must participate equally in the team. Each team will submit a report give a public presentation of its system.

E. Suggested Teaching Philosophy

Class sessions can be a combination of moderately short presentations and open discussion about the history and implications of the principles presented. Student involvement is important in achieving a view of the whole.

Prior to classes, and in addition to classes, students can be asked to read from source books and other materials. They will prepare questions from their readings and points on which they seek elaboration or clarification.

Students will write short essays on how a particular principle followed the pattern to being considered great. This develops their skills as observers of these phenomena.

In their team projects, students will be asked to contribute equally and various safeguards will be built into the operating rules for teams to assure this. All participate equally in the presentations of their projects. Project presentations give them practice in presentations and in responding to questions on the spot.