THE UNOFFICIAL GUIDE TO

# COMPUTER SCIENCE @ HARVARD

VERSION 5

WWW.CS.HARVARD.EDU

PROPERTY OF

5 CS o

CS50.NET

## DESIGNED BY CS50

*Haven't taken CS50 yet?*
*Visit* **cs50.net** *for FAQs.*

*Photograph by Eliza Grinnell*

# What is CS?

We like to say that CS teaches you how to think more methodically and how to solve problems more effectively.  As such, its lessons are applicable well beyond the boundaries of CS itself.

But CS is also, more generally, the study of information.  How do you represent it?  With what methods (aka algorithms) can you process it?

Perhaps the most liberal answer, though, is that CS "has no exclusive domain of its own, and that its importance comes from the problems to which it is applied."  And therein lies the excitement.  CS empowers you with tools and ideas that can be applied to practically any domain of interest to you, both in college and beyond.

# What is CS not?

Contrary to popular belief, CS is not really about programming, even though you do learn how to program.  Programming languages are tools that Computer Scientists use or create in order to solve problems of interest to them.

## How can I get a secondary in CS?

Take any four courses numbered 50 or higher.   See page 9 for popular study cards.  See **Computer Science** under **Secondary Fields** in the *Handbook for Students*.

## How do I concentrate in CS?

Take at least two of CS50, CS51, and CS61; take CS121 and another "theory" course; take four technical electives; and take Math 21a and Math 21b.  Plus take any of Math 1a, Math 1b, and CS20 as needed.  See page 8 for popular study cards.  See **Computer Science** under **Fields of Concentration** in the *Handbook for Students*.

## Can I change my concentration to CS?

Yes, so long as you still have time to satisfy the requirements.  Even David J. Malan '99, who now teaches CS50, didn't take his first CS course until his sophomore year, when he switched from Government to CS.

## Does CS require a thesis?

No, not for non-Honors or Honors, but for High Honors and Highest Honors, it's expected.  See **Computer Science** under **Fields of Concentration** in the *Handbook for Students*.

## Is a thesis just a big program?

No, a thesis is a research paper.  You might end up writing programs in order to evaluate your ideas, but those programs are ordinarily means to an end, not an end in themselves.  Visit **cs.harvard.edu/thesis** for examples.

## How do I graduate with Honors in CS?

Take six technical electives instead of four and have a concentration GPA in the top half of your class. See **Computer Science** under **Fields of Concentration** in the *Handbook for Students*.

## How do I graduate with High Honors in CS?

High Honors are decided by faculty vote. You must ordinarily write an "excellent thesis" to be considered. See **Computer Science** under **Fields of Concentration** in the *Handbook for Students*.

## How do I graduate with Highest Honors in CS?

Highest Honors are decided by faculty vote. You must ordinarily write an "outstanding thesis" to be considered. See **Computer Science** under **Fields of Concentration** in the *Handbook for Students*.

## Is CS part of Mind, Brain, and Behavior?

Yes! See **Computer Science** under **Fields of Concentration** in the *Handbook for Students*.

## Do any CS courses count for Gen Ed?

Yes! To satisfy Empirical & Mathematical Reasoning, take CS1, CS20, CS50, or CS171. (Note that CS1 does not count toward a concentration or secondary in CS.) To satisfy Culture & Belief, take CS105.

## Should I study CS even if I don't want to be a programmer?

Yes! CS concentrators head off in all sorts of directions after graduation. See **Figure 1** for titles that alumni since 1984 now hold. See **Figure 2** for fields in which alumni since 1984 can now be found.

## Should I activate Advanced Standing and get a fourth-year master's degree in CS?

Maybe! If you are eligible for Advanced Standing and think you could handle eight (mostly) 200-level CS courses, it's a great opportunity. Your bachelor's degree doesn't even need to be in CS, so long as you can still satisfy the prerequisites for the 200-level courses. See **Other Academic Opportunities** in the *Handbook for Students*.

## Can I do a joint concentration between CS and another field?

Yes, but you probably shouldn't. Joint concentrations are really for students who want to write a thesis on some research problem in the intersection of two fields. If you simply want to study both fields, it's generally best to get a secondary or simply take courses in CS or the other field.

---

**Figure 1:** Titles that alumni since 1984 now hold.

Figure 2: Fields in which alumni since 1984 can now be found.

## Should I concentrate or minor in CS even if I don't want to work in tech?

Yes! CS empowers you to solve problems in all sorts of domains. Here's where alumni since 1984 can be found:

**033 Asset Management** · 2Wire Inc. · **AAA Northern California, Nevada, Utah** · Ab Initio Software Corporation · **Acccenture** · Accel Partners · **Accenture** · Access Global Partners · **Action Verb LLC** · Active Endpoints, Inc. · **Acumen Fund** · AdNectar · **Adobe Systems** · Aegon · **Agile Communications, Inc** · Agilex Technologies · **AIG** · Akamai Technologies · **Alliance Growth Equities** · Alverno College · **Amazon.com** · Amdocs · **American Express** · Andera, Inc. · **Angelo, Gordon** · Apple, Inc. · **AQR Capital Management** · Aravo Solutions · **AristoDigital** · Asprova Corporation · **AT Kearney Inc** · Athenahealth, Inc. · **Authoria, Inc.** · Autodesk Inc · **Autonomy** · Bain Capital · **Bainwood Huang & Associates** · Barclays Capital · **BBN Technologies** · Beaver Lakefront Resort, Inc. · **Bee North, LLC** · Bellevue Hospital Center · **Bessemer Venture Partners** · Big Tent Design · **Bingham McCutchen** · Blackhorse Asset Management · **Bloomberg, LP** · Blue Cross Blue Shield of North Carolina · **BlueCrest Capital Management Ltd** · Booz Allen Hamilton · **Boston Consulting Group** · Boston Harbor Ship Yard and Marina #F3 · **Boston University** · Briar Rose LLC · **Bridgewater Associates** · Bronto Software, Inc · **Building Educated Leaders for Life** · CA, Inc. · **California State University - Hayward** · Caltech · **Cambridge Semantics** · Cardozo School of Law · **Carnegie Mellon University** · Children's Hospital · **Ciplex.com** · Citigroup · **ClearNow, Inc.** · Clever Machine · **Cliff Island Software** · CNA Insurance · **CoBu Technology** · Code Red · **Cognex Corp** · Colorado Technical University - Kansas City · **Columbia Presbyterian Hospital** · Columbia University/Harlem Hospital Center · **CommonMind LLC** · Computational Models Inc · **Computer Partners Inc** · Congregation B'nai Torah · **Contra Costa Community College District** · Council on Spiritual Practices · **Credit Suisse** · Credit Suisse First Boston · **CrossTech Group** · CTB/McGraw-Hill · **Cuil** · D. E. Shaw & Co. · **Daiwa Securities America** · Dangermarc Studios · **Daniel's Jewelers** ·

Danoo, Inc. · **Dartmouth Medical School** · Data Deletives · **Davis Polk & Wardwell** · DE Shaw & Co. · **Deloitte & Touche** · Department of Justice · **DeSales University** · Deutsche Bank · **Diamond Management & Technology Consultants** · Dimagi Inc. · **Dixie State College** · DOE/National Nuclear Security Administration · **DoubleClick Inc.** · DoubleDyno, Inc. · **Dowling & Partners Securities, LLC** · Draper Fisher Jurvetson · **Eastport Analytics Inc** · Eastwan Kodak Co · **Effici LLC** · Electroactive Inc · **Ellington Management Group** · EMC Corporation · **EMC\*2 Corp.** · Endeca Technologies · **Entelos, Inc.** · etrials Worldwide, Inc · **Evans Griffiths & Hart, Inc** · Facebook · **FAS Computer Services** · Feith Systems & Software, Inc. · **Feldman Gale, P.A.** · Fidelity Investments · **First Potomac Realty Trust** · Fish & Richardson P. C. · **Five Oaks Technologies, Inc.** · Flixster, Inc. · **Fluidnet** · Flybridge Capital Partners · **Fore Research and Management** · Forest View Elementary School · **Franklin W Olin College of Engineering** · Fred Hutchinson Cancer Research Center · **frog design** · Gao Hua Securities Limited · **Gartner, Inc** · Genentech, Inc. · **Goldman Sachs** · Google · **Goose Networks, Inc.** · Greater Greater Washington · **GreenRoad Technologies Inc** · Greenwich Capital · **Guardian Technologies International, Inc.** · Guidewire Software · **Harvard Business School** · Harvard College · **Harvard University** · Hasbro, Inc. · **Highland Financial Holdings Group** · HLCSoft · **Holland & Davis LLC** · Horizon Asset International Limited · **Howard Rice Nemerovski Canady Falk & Rabkin** · Hyperion Solutions · **Idiom Technologies** · IL2000 · **iLike** · Imagen Incorporated · **IMakeNews, Inc.** · Immunity, Inc. · **Index Ventures** · Industry Aspect LLC · **Information Builders Inc** · Ingeeni Studios, Inc. · **Integrative Bodywork** · Intel Corporation · **Intel Semiconductor Ltd** · Interactive Factory · **InterfaceThis** · International Air Transport Association · **International Business Machines** · Intuit · **ISI** · iSkoot, Inc. · **JP Morgan** · J2 Interactive LLC · **Jamison Group** · Janus Capital Group · **Jefferies International Limited** · Jones Day · **Joy Health &**



*Photograph by Dan Armendariz*

**Wellness, LLC** · Juniper Networks · **KANTOR Management Consultants** · Katzenbach Partners LLC · **Keane, Inc** · Khosla Ventures · **Kiva Microfunds** · Knesset of Israel · **Knobbe Martens Olson & Bear LLP** · Kowintec, Inc · **Krauss Dermatology** · La Quinta High School · **Legacy Investments, Inc** · Legg Mason · **Linden Lab** · LinkedIn · **Liquid Machines** · Lithium · **Lonely Planet** · Lontra · **LookSmart** · LucidEra · **Mack Scogin Merrill Elam Architects** · Mage Sports, LLC · **Marathon Asset Management** · Marin Academy · **Marin Software** · MarketMind Technologies · **Marsh Croft Property Group, LLC** · Masergy Communications · **Massachusetts General Hospital** · Match.com · **Maveron** · McKinsey & Company · **McKinsey & Company, Israel** · McMaster-Carr Supply Company · **MDCIV, Inc.** · MDT Advisers · **Medtronic** · Mercatus LLC · **Mercer Management Consulting** · Metacapital Management · **Metaphor Computer** · Micro Office Solutions · **Microsoft** · Microsoft Research · **Mindworks Software LLC** · MIT · **MIT Computer Science and AI Lab** · MIT Lincoln Laboratory · **MLB Advanced Media** · MobiTech 3000 LLC · **Morgan Stanley** · Morgan Stanley Smith Barney · **Morse, Barnes-Brown & Pendleton, P.C.** · Mozilla Corporation · **MySpace** · Nassau University Medical Center · **National Institute of Standards and Technology** · National Institute on Aging · **National Institutes of Health** · Network Appliance · **Network Appliance, Inc.** · Neufeld Scheck & Brustin, LLP · **New Enterprise Associates** · New Mountain Capital LLC · **New York Law School** · nextstop.com · **NFL** · Nintendo Technology Development, Inc. · **Northeast Orthopaedic Specialists, PC** · Northeastern University · **Numeric Investors LLC** · Ocala Eye · **Olympian Gaming, LLC** · OPNET Technologies · **Opnet Technology** · Optaros Inc · **Oracle / BEA Systems / Plumtree Software** · Oracle Corporation · **Orange Academy** · Orion IT Services · **Outbound Light Group** · Outcome Sciences, Inc · **Parfums Christian Dior** · Passport Technologies · **Patterson Harkavy LLP** · Paulson & Co., Inc. · **PDI/ Dreamworks Animation** · Peerspin, Inc. · **Philadelphia VA Medical Center** · Phillips & Nelson Media · **PictureCode** · Pittsburg Unified School District · **Pivot Inc.** · Pivotal Labs · **Pixar Animation Studios** · Pleco Software · **Pluralsight** · PopCap Games, Inc. · **Positive Energy** · Princeton University · **Procter & Gamble** · Project Einstein, Inc. · **Protea Systems** · Publishers Circulation Fulfillment, Inc. · **Pyramid Research** · Qualcomm Flarion Technologies · **Quia** · Quorum Federal Credit Union · **QVT Financial LP** · Random Walk Computing · **Raytheon** · RBC Capital Markets Corporation · **Reach Network** · Rembrandt IP Management, LLC · **Renaissance Technologies** · Reservoir Labs · **Resource Capital Group** · Richland District Two · **Robbins Russell Englert Orseck Untereiner & Sauber LLP** · Round Two, Inc. · **Salt River Project** · Samasource.org · **Sears Holdings, Inc.** · Seaweed Systems Inc · **ServiceMaster Chesapeake** · Sevanta Systems · **Sharpcast** · Shaw Systems Associates Inc · **Shelflink Inc** · Shumway Capital · **SiBEAM, Inc** · Sienna Ventures · **Skyward Mobile** · Slide · **Small Business Administration** · SmartDraw.com · **SmartTurn** · SNiP · **Solid Concepts Company** · SRI International · **St. Catharine's College** · St. Luke's Roosevelt Hospital Center · **State Street Associates** · State Street Global Advisors · **Stentor Inc** · Strake Jesuit College Preparatory School · **Suburban Radiologists, S.C.** · Sun Microsystems · **SunGard Higher Education** · SunTrust · **Symantec Corporation** · Tandberg · **Techcelerator** · Tellme Networks · **Teradyne Inc** · The Cutler Group · **The Invus Group LLC** · The Walt Disney Company · **Third Sky Inc** · TIBCO Software Inc · **Ticketmaster Inc** · Tom Stone Gallery · **Topix.net** · TrafficBroker · **Treehouse Enterprises** · TripAdvisor Inc · **TTI-C** · Tudor Investment · **Tufs University** · Tulane Law School · **Two Sigma Investments** · Tykhe Capital LLC · **U.S. Federal Government** · UBS Financial Services · **UCSF** · Union College · **Univ. of Southern California** · University of Auckland · **University of California, Berkeley** · University of Maryland · **University of Maryland, College Park** · University of Michigan · **University of Minnesota** · University of New Hampshire · **University of Pennsylvania** · University of Washington · **US Agency for International Development** · US Foodservice · **US Secret Service** · Vanderbilt University · **Vanderbilt University Medical Center** · Venrock · **VidaTech Incorporated** · Viewlogic Systems · **ViPS** · Virgin HealthMiles, Inc. · **VistaPrint** · Visto Corp · **VMware, Inc** · VMware, Inc. · **Washington State 8th District** · Weight Watchers International · **Weill Cornell Medical College** · Windward Mark Interactive · **Wireless Generation** · WorldChain Inc · **Xaraf Management LLC** · Xaverian Brothers High School · **Yahoo!** · Yale University · **Yam's Electronics Fty Ltd** · Yieldex · **Zantaz Inc.** · Zappos.com, Inc. · **zeo Capital Advisors, Inc.** · Zyasoft LLC

*Photograph by Titus Jahng*

## Can I do research in CS?

Yes! Many CS courses offer opportunities for research, particularly 200-level courses. And you can take CS91r to work one-on-one with faculty. Students and faculty do research in all sorts of areas, including, but not limited to:

- Artificial Intelligence and Computational Linguistics
- Computation and Economics
- Graphics, Visualization, and Imaging
- Human-Computer Interaction
- Information, Systems, and Networks
- Intelligent Systems and Computer Vision
- Languages, Compilers, and Operating Systems
- Multi-Agent Systems
- Privacy and Security
- Theory of Computation

## Will everyone in CS know more than me?

No! Contrary to popular belief, not every Computer Scientist has been programming since childhood! In fact, 76% of the students who took CS50 in Fall 2011 had never taken a CS course before. Only 18% had taken one, and only 6% had taken two or more, per **Figure 3**.
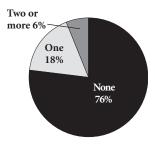


**Figure 3:** CS50 is most students' very first course in CS. 76% of the students who took CS50 in Fall 2011 had never taken a CS course before; 18% had taken one; and 6% had taken two or more.

# Popular Study Cards for Concentrators

Plenty of other combinations are possible.
Graduate-level (200-level) courses are also allowed!

### For late converts to CS

- AM21b: Mathematical Methods in the Sciences
- CS20: Discrete Mathematics for Computer Scientists
- CS50: Introduction to Computer Science I
- CS61: Systems Programming and Machine Organization
- CS121: Introduction to Formal Systems and Computation
- CS124: Data Structures and Algorithms
- CS141: Computing Hardware
- CS171: Visualization
- CS179: Design of Usable Interactive Systems
- CS182: Intelligent Machines: Reasoning, Actions, and Plans
- Math 1a: Introduction to Calculus
- Math 1b: Calculus, Series, and Differential Equations

### For those without prior college-level math, interested in human-computer interaction

- AM21a: Mathematical Methods in the Sciences
- AM21b: Mathematical Methods in the Sciences
- CS20: Discrete Mathematics for Computer Scientists
- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS61: Systems Programming and Machine Organization
- CS105: Privacy and Technology
- CS121: Introduction to Formal Systems and Computation
- CS124: Data Structures and Algorithms
- CS171: Visualization
- CS179: Design of Usable Interactive Systems
- CS182: Intelligent Machines: Reasoning, Actions, and Plans
- Math 1a: Introduction to Calculus
- Math 1b: Calculus, Series, and Differential Equations

### For those with stronger math backgrounds, interested in hard-core systems

- AM21a: Mathematical Methods in the Sciences
- AM21b: Mathematical Methods in the Sciences
- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS61: Systems Programming and Machine Organization
- CS121: Introduction to Formal Systems and Computation
- CS124: Data Structures and Algorithms
- CS141: Computing Hardware
- CS143: Computer Networks
- CS152: Programming Languages
- CS161: Operating Systems
- CS165: Information Management
- CS175: Computer Graphics

### For budding theorists writing theses

- AM106: Applied Algebra
- AM107: Graph Theory and Combinatorics
- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS91r: Supervised Reading and Research
- CS121: Introduction to Formal Systems and Computation
- CS124: Data Structures and Algorithms
- CS141: Computing Hardware
- CS152: Programming Languages
- CS175: Computer Graphics
- CS222: Algorithms at the Ends of the Wire
- Math 25a: Honors Linear Algebra and Real Analysis I
- Math 25b: Honors Linear Algebra and Real Analysis II

### For those interested in machine intelligence

- AM21a: Mathematical Methods in the Sciences
- AM21b: Mathematical Methods in the Sciences
- CS20: Discrete Mathematics for Computer Scientists
- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS61: Systems Programming and Machine Organization
- CS121: Introduction to Formal Systems and Computation
- CS124: Data Structures and Algorithms
- CS141: Computing Hardware
- CS165: Information Management
- CS182: Intelligent Machines: Reasoning, Actions, and Plans
- CS187: Computational Linguistics
- CS189r: Autonomous Multi-Robot Systems

# Popular Study Cards for Secondaries

Plenty of other combinations are possible. Graduate-level (200-level) courses are also allowed!

### For "those less comfortable"

- CS50: Introduction to Computer Science I
- CS105: Privacy and Technology
- CS171: Visualization
- CS179: Design of Usable Interactive Systems

### For "those more comfortable"

- CS51: Introduction to Computer Science II
- CS61: Systems Programming and Machine Organization
- CS121: Introduction to Formal Systems and Computation
- CS161: Operating Systems

### For those interested in data

- CS50: Introduction to Computer Science I
- CS124: Data Structures and Algorithms
- CS165: Information Management
- CS171: Visualization

### For those interested in economics

- CS51: Introduction to Computer Science II
- CS121: Introduction to Formal Systems and Computation
- CS182: Intelligent Machines: Reasoning, Actions, and Plans
- CS186: Economics and Computation

### For those interested in efficiency

- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS121: Introduction to Formal Systems and Computation
- CS124: Data Structures and Algorithms

### For those interested in graphics

- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS171: Visualization
- CS175: Computer Graphics

### For those interested in hardware

- CS50: Introduction to Computer Science I
- CS61: Systems Programming and Machine Organization
- CS141: Computing Hardware
- CS148: Design of VLSI Circuits and Systems

### For those interested in life sciences

- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS124: Data Structures and Algorithms
- CS171: Visualization

### For those interested in management

- CS50: Introduction to Computer Science I
- CS105: Privacy and Technology
- CS124: Data Structures and Algorithms
- CS165: Information Management

### For those interested in math

- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS121: Introduction to Formal Systems and Computation
- CS124: Data Structures and Algorithms

### For those interested in networks

- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS143: Computer Networks
- CS144r: Networks Design Projects

### For those interested in programming languages

- CS51: Introduction to Computer Science II
- CS61: Systems Programming and Machine Organization
- CS152: Programming Languages
- CS153: Compilers

### For those interested in robotics

- CS51: Introduction to Computer Science II
- CS121: Introduction to Formal Systems and Computation
- CS182: Intelligent Machines: Reasoning, Actions, and Plans
- CS189r: Autonomous Multi-Robot Systems

### For those interested in speech recognition

- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS182: Intelligent Machines: Reasoning, Actions, and Plans
- CS187: Computational Linguistics

### For those interested in software development

- CS50: Introduction to Computer Science I
- CS51: Introduction to Computer Science II
- CS124: Data Structures and Algorithms
- CS164:  Mobile Software Engineering

# Life after 50

You can head off in all sorts of directions after CS50, but here are some popular routes. See **Computer Science** in the *Courses of Instruction* for prerequisites.

**FALL**

**SPRING**

**CS148**
Design of VLSI Circuits and Systems

**CS179**
Design of Usable Interactive Systems

**CS171**
Visualization

**CS141**
Computing Hardware

**CS164**
Mobile Software Engineering

**CS124**
Data Structures and Algorithms

**CS50**
Introduction to Computer Science I

**CS105**
Privacy and Technology

**CS20**
Discrete Mathematics for Computer Scientists

**CS51**
Introduction to Computer Science II

**CS61**
System Programming & Machine Organization

**CS121**
Introduction to Formal Systems & Computation

**CS152**
Programming Languages

**CS143**
Computer Networks

**CS187**
Computational Linguistics

**CS165**
Information Management

**CS153**
Compilers

**CS175**
Computer Graphics

**CS161**
Operating Systems

**CS181**
Intelligent Machines: Perception, Learning, and Uncertainty

**CS186**
Economics and Computation

**CS182**
Intelligent Machines: Reasoning, Actions, and Plans

**CS189r**
Autonomous Multi-Robot Systems

**CS144r**
Networks Design Projects