Guide to the MSCS Program Sheet

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Welcome to the Stanford Computer Science Department! This guide is designed to help you understand the requirements for the Master of Science in Computer Science (MSCS) and, more specifically, how to use the MSCS program sheet which details your specific course of study leading to the degree.

The MSCS program sheet

The central requirement for the MSCS degree is completion of at least 45 units that represent an approved academic plan. The concrete representation of that academic plan is your program sheet, which lists the courses you intend to use to satisfy the 45-unit requirement. Separate program sheets for each of the pre-approved areas of specialization are available online on GIN (the Gates Information Network, http://gin.stanford.edu), and as downloadable files from **cs.stanford.edu/degrees/mscs/programsheets/.**

You must file your initial program sheet before the end of your first registered quarter as a MSCS student. Filing the program sheet, however, does not lock you into taking exactly the set of courses you originally propose. The best way to think about your program sheet is as a contract between you and the department detailing the requirements for the degree. Completing the courses in your approved plan—as long as you fulfill the general requirements that apply to all degrees—will entitle you to graduate with the MSCS degree in your chosen area of specialization. If you need to change your plan of study, you must simply renegotiate the contract, which means filing a new program sheet that represents your updated course of study. You must get your adviser's signature (or virtual signature) on the revised plan but need not get new signatures for individual courses that were approved on a previously filed program. For example, if you have already gotten approval from your adviser to count courses from another institution toward your Foundations requirements, you need not get those signatures again.

The important thing to remember is that, before you will be cleared for graduation, you must have a program sheet on file that matches the courses you have in fact completed. If you decide to change your course of study, you should get a new program sheet signed as soon as possible to ensure that the changes are approved. If you wait until your final quarter and approach your adviser with a program that differs substantially from your original program, you may find that you need additional quarters to complete an approved course of study. By keeping your program sheet up to date, you can be confident that the program you are pursuing is in fact sufficient for the MSCS degree.

Foundations requirement

Students come to the Stanford MSCS program with a wide variety of backgrounds. Some of you have recently completed undergraduate degrees in computer science, while others are taking your first formal computer science courses in many years. The MSCS program is flexible enough for you to design a program that starts at the appropriate level. The Foundations requirement is reflective of the elementary knowledge in CS we expect students to have gained previously through their undergraduate programs. At Stanford, these foundations are represented by the following courses (listed in Figure 1 below):

Figure 1. Foundations requirement

Required:	Equivalent elsewhere	Approval	Grade	Units
Logic, Automata and Complexity (CS 103)				
Probability (CS 109 or Stat 116 or CME 106 or MS&E 220)				
Algorithmic Analysis (CS 161)				
Computer Organ & Systems (CS 107 or 107E)				
Principles of Computer Systems (CS 110 or 111)				

If you have taken these courses—either at Stanford or equivalent courses elsewhere—you have satisfied these requirements. If you have taken an equivalent course elsewhere and have received at least a B, you can use that course to satisfy the corresponding Foundations requirement, as long as you secure the approval of your adviser. The individual descriptions in Figure 2 include a brief summary of what we expect from each of the Foundations courses so that you will have a better idea of whether the courses you have taken will satisfy the requirement. Note that in some cases, you may have completed equivalent coursework to a single course here through taking *more than one* course at another institution. As a result, in deciding if you have taken previous equivalent coursework, it is important to not simply consider a one-to- one course equivalence, but rather the topical content of courses. For example, three courses from another institution may cover the same topics as two courses in the Foundations requirements, but with the topics organized in a different manner. You are required to satisfy all the Foundations requirements, either by waiving out of courses or by taking them at Stanford (or some combination thereof). Note that using a course from another institution to satisfy your Foundations requirements does not give you any units toward the MSCS degree; it merely relieves you from the responsibility of taking that particular course as part of your Stanford degree. By using courses from other institutions to satisfy your Foundations requirements, you give yourself time to take more advanced courses. The program you submit for your degree may count at most 10 units of Foundations courses (taken at Stanford, not waived) toward your degree. If you have to take more than 10 units of Foundations courses, you will likely end up having to take more than 45 total units to complete your degree.

It is also important to understand that only *coursework* can be used to satisfy the Foundations requirement. It is not sufficient to claim that you have already learned the material in some area on your own. At the same time, it is in no one's best interest to have you repeat material that you already know. If a course that's listed in the Foundations category would be too elementary, you can usually satisfy the requirement by taking a more advanced course in the same area. If, for example, you believe that you already know everything that CS161 would teach you about algorithmic analysis, take CS261 instead and ask your adviser to count it as your Foundations requirement. In general, and with the approval of your adviser and the MS program administrator, you should feel free to substitute more advanced courses for courses listed as requirements if you are ready to do the work at that level.

Sometime early in your first quarter—preferably in the first week or two—you should contact your academic advisor to go over your Foundation requirements. If you have taken courses that you would like to use in fulfillment of these requirements collect the required supporting documents online at http://gin.stanford.edu (log in with your CS ID and password, and click on 'Dashboard' to find the waivers link), and route to your adviser to request approval of a course waiver or waivers. You may need to do some convincing. You should be prepared to answer simple questions about the material covered in the course(s) you are seeking to replace. The final decision is up to your adviser. If you can convince your adviser that you have learned the material in a previous course, you can skip the specific requirement and move on to more advanced material. If you cannot convince your adviser, you will have to take the course at Stanford.

Figure 2. Brief descriptions of courses meeting the foundations requirements

1. **Logic, Automata and Complexity (CS 103).** To satisfy this requirement, students should have taken coursework covering essential mathematical concepts in computing, including logic, proof techniques, discrete structures (sets, functions, and relations), automata and complexity theory. Students should have an understanding of how to construct a formal proof and various standard proof techniques (direct proof, proof by contradiction, induction, diagonalization). Additionally, students should have significant exposure to finite automata, regular expressions, context-free grammars, Turing Machines, computability (e.g., decidability and the halting problem), and computational complexity including a rigorous treatment of NP-Completeness. Note that this requirement is most likely fulfilled by more than one course at many other institutions.

2. **Probability (CS 109, Stat 116, MS&E 220, CME 106, or EE 178).** The Foundations requirement in statistics can usually be satisfied by any course in probability taught from a rigorous mathematical perspective. Courses in statistics designed for social scientists generally do not have the necessary sophistication. A useful rule of thumb is that courses satisfying this requirement must have a calculus prerequisite.

3. **Design and Analysis of Algorithms (CS 161).** The most important thing to realize about CS161 is that it covers material at a higher level of mathematical sophistication than many courses on algorithms at other institutions. A course in "Data Structures and Algorithms" taught—as it is in many schools—as the second programming course would not satisfy this requirement. In general, if you want to use a course from another institution in place of CS161, that course should list both the introductory programming sequence (the equivalent of Stanford's CS106 series) and the introductory theory course (Stanford's CS103) as prerequisites.

4. **Computer Organization and Systems (CS 107 or 107E).** This course gives students a basic understanding of computer systems from the hardware level up the source code level. Such familiarity should include concepts such as basic computer organization (e.g., registers, ALUs, memory, addressing, program control, runtime stack, etc.), memory models (data representation, pointers), and fundamentals of compilation (simple assembly code, basics of code generation, linking, and loading).

5. **Principles of Computer Systems (CS 110 or 111).** Students should have an understanding of the fundamental principles of computer systems (processes, file systems, concurrency) as well as elements of networking and distributed systems. Students should understand the facilities provided by modern operating systems and networks as well as how to use them (e.g., spawning processing, making remote procedure calls, virtual memory, caching, scheduling, etc.), although they need not have actually implemented portions of an operating system kernel. Students should have the ability to develop designs, abstractions, and appropriate modularity in the larger pieces of software they develop.

The following summarizes the rules for satisfying the Foundations requirements:

- You must complete the Foundations requirements. The Foundations requirements may be satisfied through course waivers, completing coursework at Stanford, or some combination thereof.

- If you take one of the Stanford courses listed on the program sheet for a particular requirement, you satisfy the corresponding requirement directly and do not need to get your adviser's approval.

- If you have already taken equivalent coursework at another institution and have received at least a B in that coursework, you may ask your adviser to accept that coursework as satisfying the Foundations requirement in that area. To do so, fill in the details of the substituted course on your program sheet, collect the required supporting documents online at http://gin.stanford.edu, and hit 'submit' to route the waiver request(s) to your advisor.

- If you use coursework from another institution to satisfy the Foundations requirements in a particular area, that coursework does not count for any units in the Stanford program. The advantage of using a previous course to fill a Foundations requirement is simply that it allows you to take more advanced courses in your program. It does not reduce the number of units you will have to complete.

- You may count no more than 10 units from the set of courses listed under the Foundations requirement category. If you need to take more courses in that category, your program will likely have to include more than 45 total units.

Significant implementation requirement

In order to complete an MS CS, students must demonstrate the ability to do substantial software development as part of their coursework. To satisfy the Significant Implementation (SI) requirement, students complete a course designated as satisfying the SI requirement. This course will be one of the courses taken to satisfy some other program requirement (i.e., Breadth, Depth, or Elective). Note that the SI requirement must be satisfied by coursework at Stanford – this requirement may not be waived by coursework elsewhere. (Coterminal students who took <u>two</u> courses with the SI designation as part of their undergraduate programs may waive out of this requirement.)

Figure 4. Approved significant implementation courses

CS 140/212. Operating Systems and Systems Programming

CS 140E. Operating Systems Design and Implementation (Embedded)

CS 143. Compilers

CS 144. Introduction to Computer Networking

CS 145. Introduction to Databases

CS 148. Introduction to Computer Graphics and Imaging

CS 151. Logic Programming

CS 190. Software Design Studio

CS 210B. Software Project Experience with Corporate Partners

CS 221. Artificial Intelligence: Principles and Techniques

CS 227B. General Game Playing

CS 231N. Convolutional Neural Networks for Visual Recognition

CS 243. Program Analysis and Optimizations

CS 248/248A. Interactive Computer Graphics

CS 341. Project in Mining Massive Data Sets

Breadth requirement

The Master of Science degree in Computer Science indicates two things to prospective employers. First, it guarantees that you have a broad grounding in computer science as a discipline. Second, it certifies that you have studied a particular area in detail and thus have additional depth in a particular specialty. Both components are important to the Master's program, and it is not possible to secure a Stanford MS CS degree that does not meet both requirements.

The breadth requirement must be satisfied by course work at Stanford – this requirement may not be waived by course work elsewhere. All course work must be taken for a letter grade[*] and each course must be 3 or more units. Coterminal students must take breadth courses in their graduate career.

There are four breadth Areas (A, B, C and D). Three courses must be completed, each from a different Area. We expect that one course will also satisfy a depth requirement, and two courses will be used as electives.

Area A. Mathematical and Theoretical Foundations: CS 154, 157, 168, 254, 261, 265; EE 364A, 364B; Phil 251

Area B. Computer Systems: CS 140, 140E, 143, 144, 149, 212, 242, 243, 244, 244B, 295, 316, 358; EE 180, 282, 382E

Area C. Applications: CS 145, 147, 148, 155, 173, 221, 223A, 224N, 224U, 224W, 227B, 228, 229, 229M, 231A, 231N, 234, 236, 237A, 245, 246, 247 (any suffix), 248/248A, 251, 255, 273A, 273B, 279, 345, 347, 348A, 348B, 348C, 348E, 348I, 348K, 355, 356, 373

Area D. Computing and Society: CS 152, 181, 182, 256, 281, 329T, 384; AMSTUD 133, 145; ANTHRO 132D; COMM 118S, 120W, 124, 130D, 145, 154, 166, 186W, 230A, 230B, 230C; DESINST 215, 240; EARTHSYS 213; ENGLISH 184D; ENGR 131, 248; HISTORY 244F; INTLPOL 268; LAW 4039; ME 177; MS&E 193, 231, 234, 254; POLISCI 150A; PSYCH 215; PUBLPOL 103F, 353B

Depth requirement

Students are required to complete 21 units of course work in their chosen specialization area, satisfying the specific requirements of that specialization. Most students complete one of the nine approved specializations listed in Figure 5 but you may also petition the MSCS committee to approve a specialization of your own design. In order to be approved, individually designed specializations must represent a coherent area of study and must include courses at both the 200 and 300 level. All Depth courses must be taken for a letter grade[*], each course must be 3 or more units, and no more than 6 units of CS399 Independent Study can be included.

The requirements for the pre-approved specializations are shown in Figure 5. In most cases, a specialization consists of a set of required courses, a larger set of courses out of which you must select some subset, and a larger set from which you select additional courses to fill out the 21 unit requirement. For any pre-approved specialization, you should simply select the courses on the program sheet that you have or plan to take.

Figure 5. Approved specializations

1. **Artificial Intelligence**
   a. CS 221
   b. At least four of: CS 223A, 224N, 224S, 224U, 224V, 224W, 228, 229, 231A, 231N, 234, 237A, 237B, 238
   c. A total of at least 21 units from (a), (b) and the following: CS 205L, 224R, 225A, 227B, 229M, 230, 233, 235, 236, 239, 246, 257, 270, 271, 273A, 273B, 274, 275, 279, 281, 322, 324, 325B, 326, 327A, 329, 330, 331B, 332, 333, 345, 348N, 361, 368, 371, 375, 377**, 379**, 398, 399**, 428A, 428B, 432; EE 263, 276, 278, 364A, 364B, 378B; ENGR 205, 209A; MS&E 226, 252; PSYCH 209; STATS 202, 315A, 315B

2. **Computational Biology**
   a. One of the following: CS 173, 273A. Students with equivalent coursework may waive with approval of their advisor.
   b. CS 221
   c. Two of the following: CS142, 145, 246, 448B
   d. Three of the following: CS 279, CS 371; BIOMEDIN210, 214, 215, 217, 219, 220, 222, 223, 245, 260, 273, IMMUNOL 207
   e. A total of at least 21 units from (a), (b), (c), (d) and the following: CS 124, 131, 147, 148, 154, 223A, 224N, 224S, 224U, 228, 229, 229M, 229T, 230, 231A, 231C, 231N, 234, 237A, 238, 248/248A, 399; BIO 183, 187; BIOMEDIN 248B; STATS 215, 256

3. **Computer and Network Security**
   a. Each of the following: CS 140 (or 140E or 112 or 212)**, 144**, 155, 255, 356
   b. At least three of the following: CS 142, 190, 240, 244, 244B, 249I, 253, 261, 265, 340, 344 (any suffix), 355
   c. A total of at least 21 units from (a), (b) and the following: CS 245, 251, 294S**, 345, 399**; EE 384A, 384S

4. Human-Computer Interaction

    a.   CS 147, 247 (any suffix), 347, 142. CS147 may only be waived if an equivalent course has previously been completed for academic credit at another institution

    b.   One of: CS 278, 448B. If one of these courses was taken for another Stanford degree, a different one must be taken for the MS; if both of these courses were taken for another Stanford degree, this requirement can be waived.

    c.   At least two additional courses from category (b) or the following: CS 194H, 206, 210A, 247 (any suffix), 377 (any suffix and 3 or more units)

    d.   A total of at least 21 units from (a), (b), (c) and the following: ArtStud 130, 160, 163, 165A, 166, 169A, 231, 264, 266, 267); Communication (Comm 224, 272, 324); Design (ME 115A, 115C, 216A, any d.school class listed at http://dschool.stanford.edu for 3 units or more and numbered 100 and above; Empirical Methods (Comm 254, 314, Educ 200B, MS&E 125, Psych 251, 252, 253, Stats 203); Learning Design & Tech (CS 498C; Educ 236, 239, 281, 342, 432); Man Sci & Eng (MS&E 184, 231, 334); Mech Eng (ME 203, 210, 216A); Music (CS 477; Music 220A, 220B, 220C, 250A, 256A); Psych (Psych 204, 209); Sym Sys 245

5. Information Management and Analytics

    a.   CS 145

    b.   At least four of: CS 224N, 224W, 229, 245, 246, 263, 276, 345

    c.   At least 21 units from (a), (b) and the following: CS 144, 151, 190, 224S, 224U, 224V, 228, 229M, 230, 231A, 231N, 233, 234, 236, 240, 242, 243, 244, 244B, 251, 255, 270, 272, 273A, 274, 275, 279, 281, 316, 320, 324, 325, 329S, 341, 344 (any suffix), 349D, 349H, 399**; MS&E 226; STAT 315A, 315B

6. Real World Computing

    a.   At least three of the following: CS 148, 223A, 231A, 248/248A

    b.   At least three of the following: CS 205L, 233, 268, 348A, 348B, 348C, 348E, 348K; CME 302, 306

    c.   At least 21 units from (a), (b), and the following: CS 146, 225A, 228, 229, 230, 232 (or EE 368), 247 (any suffix), 270, 272, 273A, 274, 294A**, 326, 327A, 328, 331B, 333, 399**, 448 (any suffix); EE 267

7. Software Theory

    a.   CS 242, 243

    b.   At least one of the following: CS 221, 244, 245, 341

    c.   At least one of the following: CS 255, 350, 355, 356

    d.   At least 21 units from (a), (b), (c) and the following: CS 151, 250, 261, 265, 294S**, 295, 315B, 349H, 357, 357S, 399**

8. Systems

    a.   Each of the following: CS 140 (or 140E or 112 or 112E or 212), 144, 240. Students with equivalent coursework may waive CS 112, 112E, 140E, 144, or 212 with adviser approval.

    b.   At least four of the following: CS 190, 242, 243, 244, 245, 248/A, 348B; EE 271, 282

    c.   At least 21 units from (a), (b) and the following: CS 149, 217, 241, 244B, 246, 251, 255, 269Q, 270, 272, 276, 294S**, 315B, 316, 340, 341, 343D, 344 (any suffix), 348A, 348C, 348E, 348I, 348K, 349 (any suffix), 356, 357S, 399**, 448 (any suffix); EE 267, 273, 382C, 384A, 384C, 384S

9. Theoretical Computer Science

    a.   CS 154, 261. Students with equivalent coursework may waive CS 154 with adviser approval.

    b.   Sufficient additional units selected from: CS 151, 163, 166, 168, 228, 233, 236, 246, 250, 251, 254, 254B, 255, 256, 257, 259Q, 263, 265, 269I, 269O, 341, 345, 351, 354, 355, 358, 359**, 359D, 368, 369**, 369O, 399**, 468**; MS&E 310, 319

Note: Multiple CS359, CS369, and/or CS468 courses may be taken as long as they are each on different topics (denoted by different suffixes)

** With consent of advisor.

Specializations do allow some flexibility. If you have a particularly strong background, for example, you may already have taken some of the courses required for your area of specialization. You may also find that you are unable to complete the precise set of requirements because of course-scheduling conflicts or because certain courses are not offered in every year. Thus, it sometimes happens that the specialization you propose differs in some respect from the stated requirements.

To allow for the necessary flexibility, your adviser has some authority to approve exceptions to the requirements listed in Figure 5. It is always appropriate, for example, for the adviser to approve more advanced work in lieu of specific requirements that you have already taken elsewhere. Beyond standard substitutions such as this, advisers will approve only minor changes in the specialization requirements. If you propose more extensive deviations from the standard specializations, advisers will refer those changes to the MSCS committee for review. The general rule is that advisers have the authority to approve a *single* course change in the stated depth requirements as long as they believe that the change makes good academic sense and does not weaken the overall program. If you propose a specialization that differs from the stated requirements in two or more courses, your revised program is referred back to the full committee. The MSCS committee is empowered to approve any course proposal, but is generally not willing to support major changes in the requirements unless there are compelling reasons to do so.

Electives

After you have filled in the courses in the various areas described in the preceding sections, you may still fall short of the 45 units required for a MSCS degree, particularly if you have satisfied most of the Foundations courses with previous study at other institutions. If you are short of units, you must specify additional electives to bring your program up to the required 45-unit level.

Elective courses are really up to you to select, even though the entire program must be approved by your adviser. Courses in computer science numbered above 111, with the exception of CS 196, 198, and 390A/B/C, are suitable as electives (note that CS 129 may not be counted towards the MS if CS 229 is being counted towards any BS or MS requirement). Non-CS courses in related departments, such as Electrical Engineering, Mathematics, and Statistics, numbered at the 100-level or above and that are technical in nature, are also likely to be approved. You may count up to a maximum of **three units** of 500-level CS seminars, CS 300, EE 380, EE 385A, or other 1-2 unit seminars offered in the School of Engineering, as Electives toward the MS degree. Courses that are completely unrelated to computer science would not normally be appropriate as electives; check with your adviser if you're unsure about a course.

Additional requirements

Several of the additional requirements listed at the bottom of the program sheet have already been covered in earlier sections of this guide. A couple of the requirements, however, deserve some additional explanation.

- *Minimum GPA requirement.* In order to receive your MSCS degree, your GPA in the courses you submit on your program sheet must be at least 3.0, which corresponds to a B in Stanford's grading scale. Note that you need not get a B in every course. All the requirement states is that the overall GPA, which is simply the average of the numeric grade weighted by the number of units in each course, must be at least a 3.0. The GPA is computed only for the courses you submit on your program sheet. If you do poorly in several courses, it may be wise for you to eliminate those courses from your program sheet and substitute other courses from

your program sheet and substitute other courses in which you have done better. Such substitutions may require you to take more than 45 units, but it is important to know that a single disastrous grade will not necessarily doom your entire program.

- *Letter-grade requirement.* This requirement is mostly self-explanatory but nonetheless deserves emphasis. At least 36 of your 45 units, *including your significant implementation course and all of the breadth and depth units submitted for your specialization(s),* must be taken for a letter grade[*]. The remaining units may be taken on a credit/no credit basis if you so choose. Seminar courses, which must be taken on an S/NC basis, are not letter-graded courses.

  [*] Courses taken for an S or CR grade in Spring 2019-20 or Autumn, Winter or Spring 2020-21 can be used to satisfy MS requirements as if taken for a letter grade.