

Upper Level Course Requirements

Proposal by Mike Hicks

Problem

There is significant demand for 42X courses (i.e., those in the information processing area). The major requirements aimed at ensuring breadth limit students' ability to take these courses. But doing so seems unnecessarily strict, as these courses exhibit significant breadth, with offerings in graphics, machine learning, computational biology, and databases.

This proposal aims to address this problem by still requiring "5 courses in 3 areas" but removing the limit of 2 courses in a single area. We discuss this proposal below, along with two alternative proposals that we think are inferior.

Background

In all, 42X is the largest area in terms of courses offered, and we are increasing our capacity to offer seats in this area, with many TTK faculty hires being made in AI, ML, VR, etc. Conversely, we are standing still in other areas, and as such tend not to staff courses as much in those areas. For example, 436 and 430 are typically offered only once per year. At the extreme, the numerical analysis (46X) area consists of only two courses, and only one of them is eligible for the degree requirements.

Here is a tally of the enrollment in 400-level, area-requirement courses since Fall'15:

Fall'15	Spring'16	Fall'16	Spring'17	Fall'17	Spring'18	Fall'18	Courses
409	302	309	403	479	496	428	41X
487	487	620	740	772	1021	863	42X
316	380	325	453	321	371	547	43X
105	176	165	181	172	249	260	45X
13	0	0	19	0	0	39	46X
1330	1345	1419	1796	1744	2137	2137	TOTAL

Offering/demand for 42X courses has significantly outpaced 41X+43X, more than doubling between Spring'16 and Spring'18. During that same period, 41X+43X together increased by only 28%. Whereas in Spring'16 this pair offered more seats than 42X, in Spring'18 it offered fewer. During the same period, 45X+46X exhibited a milder upward trend, with far fewer seats offered than the other two groupings overall. This may be a consequence of the fact that the current scheme does not require everyone to take an upper-level theory course.

In sum: The current breadth requirements have not changed even as upper-level class offerings have evolved significantly. This makes them less effective at actually enforcing breadth, and

they create an impediment to students attempting to graduate on time due to mismatched availability of seats.

Status Quo

The following was copied from the [undergraduate degree web page](#), describing the current requirements.

At the upper level, students take five (5) CMSC 400 level courses from at least three different areas with no more than two courses in a given area. An additional two (2) CMSC electives, totaling 6 credits, for the general computer science degree are also required. Students may take up to three 1 credit CS courses to fulfill their elective credits requirement. If students take more than two courses from an area, the additional courses will be counted as upper level computer science electives. Students can also count one credit winter courses towards the elective requirement, as well as independent research or study with a faculty member, and other courses at the 300 or 400 level, including special topics courses.

Area 1: Systems

CMSC 411 (3) Computer Systems Architecture
CMSC 412 (4) Operating Systems
CMSC 414 (3) Computer and Network Security
CMSC 417 (3) Computer Networks

Area 2: Information Processing

CMSC 420 (3) Data Structures
CMSC 421 (3) Introduction to Artificial Intelligence
CMSC 422 (3) Machine Learning
CMSC 423 (3) Bioinformatic Algorithms, Databases, and Tools
CMSC 424 (3) Database Design
CMSC 426 (3) Image Processing
CMSC 427 (3) Computer Graphics

Area 3: Software Engineering and Programming Languages

CMSC 430 (3) Introduction to Compilers
CMSC 433 (3) Programming Language Technologies and Paradigms
CMSC 434 (3) Introduction to Human-Computer Interaction
CMSC 435 (3) Software Engineering
CMSC 436 (3) Hand Held Programming Devices

Area 4: Theory

CMSC 451 (3) Design and Analysis of Computer Algorithms
CMSC 452 (3) Elementary Theory of Computation
CMSC 456 (3) Cryptology
CMSC 457 (3) Quantum Computation

Area 5: Numerical Analysis (choose one)

CMSC 460 (3) Computational Methods (credit will only be given for CMSC 460 or CMSC 466)

CMSC 466 (3) Introduction to Numerical Analysis (credit will only be given for CMSC 466 or CMSC 460)

Proposed Change

The favored proposal is simply the following:

At the upper level, students take five (5) CMSC 400 level courses from at least three different areas ~~with no more than two courses in a given area~~. [Rest same as before]

Analysis

This change permits students to take three courses from an area (i.e., 3-1-1), rather than two (i.e., 2-2-1), while ensuring that three areas are covered. As such, students would be able to sign up for more 42X courses and take advantage of the breadth and capacity offered there. Of course, they could also sign up for more 43X and 41X courses than the current scheme. There is some breadth in these areas too, that might be more fairly covered, e.g., 434 is quite different from 433, and 414 is quite different from 411 or 412. But, as these areas have lower capacity, the added flexibility will make it easier for students to get the courses they need to graduate, while also satisfying demand.

All course patterns currently allowed would be allowed under the proposed scheme. This makes the transition process for PCC quite easy.

Alternative Proposed Change #1

One alternative proposal is to split 42X courses into two sub-areas, thus permitting taking advantage of their inherent breadth. The changes to the current policy are simple, and highlighted below.

At the upper level, students take five (5) CMSC 400 level courses from at least three different areas with no more than two courses in a given area. An additional two (2) CMSC electives, totaling 6 credits, for the general computer science degree are also required. Students may take up to three 1 credit CS courses to fulfill their elective credits requirement. If students take more than two courses from an area, the additional courses will be counted as upper level computer science electives. Students can also count one credit winter courses towards the elective requirement, as well as independent research or study with a faculty member, and other courses at the 300 or 400 level, including special topics courses.

Area 1: Systems

CMSC 411 (3) Computer Systems Architecture

CMSC 412 (4) Operating Systems
CMSC 414 (3) Computer and Network Security
CMSC 417 (3) Computer Networks

Area 2A: Information Processing (A)

CMSC 420 (3) Data Structures
CMSC 421 (3) Introduction to Artificial Intelligence
CMSC 422 (3) Machine Learning
CMSC 470 (3) Natural Language Processing (TBA)

Area 2B: Information Processing (B)

CMSC 423 (3) Bioinformatic Algorithms, Databases, and Tools
CMSC 424 (3) Database Design
CMSC 426 (3) Image Processing
CMSC 427 (3) Computer Graphics

Area 3: Software Engineering and Programming Languages

CMSC 430 (3) Introduction to Compilers
CMSC 433 (3) Programming Language Technologies and Paradigms
CMSC 434 (3) Introduction to Human-Computer Interaction
CMSC 435 (3) Software Engineering
CMSC 436 (3) Hand Held Programming Devices

Area 4: Theory

CMSC 451 (3) Design and Analysis of Computer Algorithms
CMSC 452 (3) Elementary Theory of Computation
CMSC 454 (3) Algorithms for Data Science [TBA]
CMSC 456 (3) Cryptology
CMSC 457 (3) Quantum Computation

Area 5: Numerical Analysis (choose one)

CMSC 460 (3) Computational Methods (credit will only be given for CMSC 460 or CMSC 466)
CMSC 466 (3) Introduction to Numerical Analysis (credit will only be given for CMSC 466 or CMSC 460)

Analysis

As above, all course patterns currently allowed would be allowed under the proposed scheme.

Newly allowed course patterns permit taking greater advantage of the breadth of the offerings in the 42X area. As a consequence, they essentially permit dropping a course that might otherwise have been required from 41X, 43X, 45X, 46X in aggregate. For example, the new scheme would permit the five courses 411, 412 (Systems), 421, 422 (IP-A), and 423 (IP-B), whereas one of the 42X classes would need to be replaced with a 43X, 45X, or 46X course in the current scheme. Relaxing the limit to two courses in an area (per the favored proposal, above) would still not

allow this schedule as one of the 41X courses would have to be replaced if all 42X courses were retained.

On the other hand, the above schedule shows that three of the current areas could be avoided under this proposal, which may be viewed as a negative. One potential mitigating factor is that there is some overlap between 41X and 43X courses, so some concepts would still be covered if one area was dropped. E.g., 412 covers topics of concurrency, software engineering, handler-oriented programming, and performance tuning, meaning that it overlaps with higher-level concepts that would have been covered in 433 or 436.

Alternative Proposed Change #2

An alternative proposal discussed last summer was the following: (1) collapse the Systems and SE/PL/HCI into a single area, (2) collapse Theory and Numerical Analysis into a single area, and (3) change the “5 courses in 3 areas” requirement to be “at least one course in each area.” Highlighted differences below.

At the upper level, students take five (5) CMSC 400 level courses, **with at least one from each area**. An additional two (2) CMSC upper-level electives, totaling 6 credits, for the general computer science degree are also required. Students may take up to three 1 credit CS courses to fulfill their elective credits requirement. If students take more than **three** courses from an area, the additional courses will be counted as upper level computer science electives. Students can count **up to three** one credit winter courses towards the elective requirement as noted above, as well as independent research or study with a faculty member, and other courses at the 300 or 400 level, including special topics courses.

Area 1: **Software and** Systems

CMSC 411 (3) Computer Systems Architecture

CMSC 412 (4) Operating Systems

CMSC 414 (3) Computer and Network Security

CMSC 417 (3) Computer Networks

CMSC 430 (3) Introduction to Compilers

CMSC 433 (3) Programming Language Technologies and Paradigms

CMSC 434 (3) Introduction to Human-Computer Interaction

CMSC 435 (3) Software Engineering

CMSC 436 (3) Hand Held Programming Devices

Area 2: Information Processing

CMSC 420 (3) Data Structures

CMSC 421 (3) Introduction to Artificial Intelligence

CMSC 422 (3) Machine Learning

CMSC 423 (3) Bioinformatic Algorithms, Databases, and Tools

CMSC 424 (3) Database Design

CMSC 426 (3) Image Processing

CMSC 427 (3) Computer Graphics
CMSC 470 (3) Natural Language Processing [TBA]

Area 4: Theory and Numerical Analysis

CMSC 451 (3) Design and Analysis of Computer Algorithms
CMSC 452 (3) Elementary Theory of Computation
CMSC 454 (3) Algorithms for Data Science [TBA]
CMSC 456 (3) Cryptology
CMSC 457 (3) Quantum Computation
CMSC 460 (3) Computational Methods (credit will only be given for CMSC 460 or CMSC 466)
CMSC 466 (3) Introduction to Numerical Analysis (credit will only be given for CMSC 466 or CMSC 460)

Analysis

Very few CS students take a numerical analysis class (e.g., 115 students are taking 460 in Fall'18, and only 30 of them are CS students, out of 2400 seats total at the 400 level), so combining it with theory has little practical impact on students' choices.

This rearrangement should force a bit more breadth than the current scheme. For one, it would prevent a student from avoiding all 400-level theory courses, e.g., by taking **411, 412** (systems), **433, 434** (PL/SE/HCI), and **422** (IP). This would be disallowed in the proposed scheme, as **411, 412, 433, and 434** are part of one area (software and systems). In addition, the proposed scheme permits greater breadth within the information processing area, since three courses there would be allowed. This is useful and sensible because that information processing is so broad, including courses on AI, Computational Biology, Databases, and Computer Graphics. A student could take, for example, **421, 422, 424, 430, and 456**.

On the other hand, it limits prior flexibility in areas that were previously separate. This is the flip side of the first example above (e.g., **taking two 43X classes and two 41X classes would no longer be allowed** except by treating 1-2 of them as electives). Arguably, the overlap among the combined areas reduces the harm from lack of breadth. For example, 412 covers topics of concurrency, software engineering, handler-oriented programming, and performance tuning, meaning that it overlaps with higher-level concepts that would have been covered in 433 or 436. That said, this scheme still has the potentially perplexing including of HCI classes within the "software and systems" area, but this is no worse than the current scheme.

The major disruption of this scheme is that all students will be required to take at least one 400-level theory course. Just looking at the numbers we saw above, it seems likely that some fraction of students today are not taking a theory course.

<u>Courses</u>	<u>Fall'15</u>	<u>Spr'16</u>	<u>Fall'16</u>	<u>Spr'17</u>	<u>Fall'17</u>	<u>Spr'18</u>	<u>Fall'18</u>
42X	487	487	620	740	772	1021	863
41X+43X	725	682	634	856	800	867	975
45X+46X	118	176	165	200	172	249	299

TOTAL	1330	1345	1419	1796	1744	2137	2137
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Requiring a theory course could significantly impact both teaching habits, and may create a significant challenge for many of our students. Our graduation rate is already among the lower rates on campus, and we may not want to inflate that.