

Overview of the New Undergraduate Computer Science Curriculum

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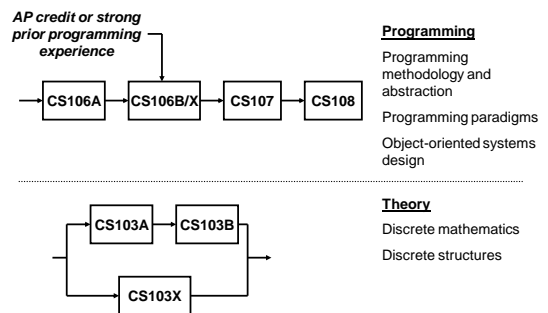
Outline

- Brief review of old CS curriculum
- The new CS curriculum
 - Structure
 - Details
- Transitioning to new program
- Resources and references

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Old Curriculum: Lower Division



Old Curriculum: Upper Division

- Theory Depth
 - CS154: Automata and Complexity Theory
 - CS161: Design and Analysis of Algorithms
- Systems Depth
 - EE108B: Digital Systems II
 - Two Systems Electives (OS, Compilers, Networking, etc.)
- Applications
 - CS121/221: Artificial Intelligence
 - One Applications Elective (Databases, HCI, Graphics, etc.)
- 2-3 Restricted CS Electives
- Senior Project capstone course

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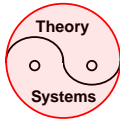
New Curricular Structure: *Core*

Theory Core: 3 Courses (CS103, CS109, CS161)

- Incorporates majority of current cs103a/b course topics
- Eliminates redundancies in existing courses
- CS-owned probability course with AI applications

Systems Core: 3 Courses (CS106B/X, CS107, CS110)

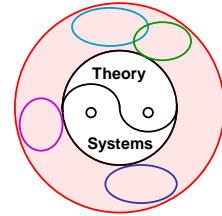
- Incorporates much of current intro programming sequence
- Incorporates systems concepts in later programming projects
- CS106A considered "funnel" into core (not part of core)



New Curricular Structure: *Tracks*

~4-5 Courses

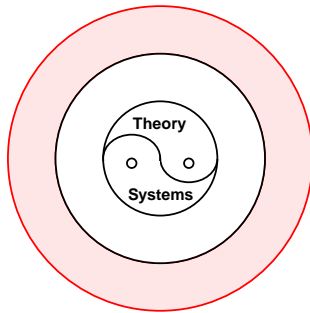
- Students must complete requirements for any one track
- Developing depth in a specialization
- Provide course options within each track
- Provide multi-disciplinary options
- Modularize curriculum



New Curricular Structure: *Electives*

~2-4 Courses

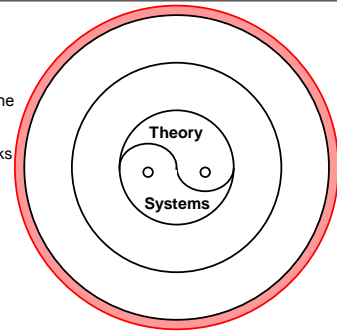
- Restricted electives
- Allow pursuing breadth and/or additional depth
- Track-specific elective options allow for interdisciplinary work



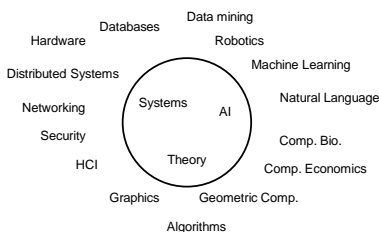
New Curricular Structure: *Capstone*

1 Course

- "Senior project" capstone course
- Developing capstone courses to parallel tracks
- Both application development and research options

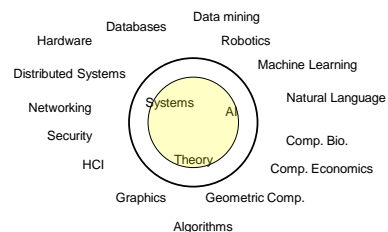


Increasing the "Footprint" of CS



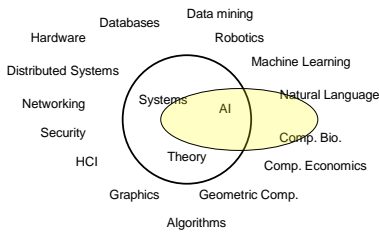
Editor's Note: Two-dimensional projection clearly does not capture the relative importance or organizational nuances of the field. Some topics may be closer to you than they appear on this slide.

"Footprint" of CS Students See Today



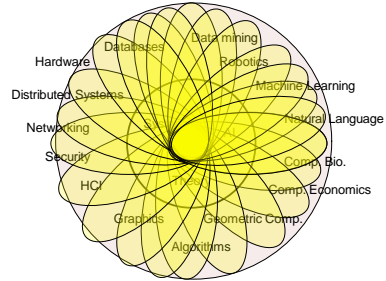
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Tracks Allow More Depth...

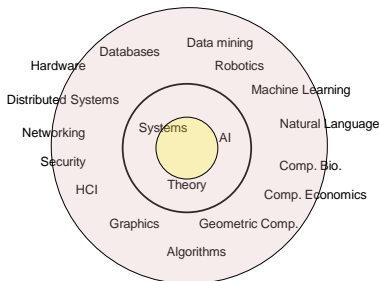


Total amount of material covered must remain the same

...in a More Diverse Set of Areas



Total Potential "Footprint" is Larger



Core material everyone sees is streamlined to accommodate

Vast Majority of CS Department Involved

Curriculum Committee

- Jerry Cain
- Bill Dally
- Vladlen Koltun
- Phil Levis
- John Mitchell
- Andrew Ng
- Nick Parlante
- Eric Roberts
- Mendel Rosenblum
- Mehran Sahami (Chair)
- Julie Zelenski

Beyond the Committee

- Alex Aiken
- Serafim Batzoglou
- Gill Bejerano
- David Dill
- Ron Fedkiw
- Hector Garcia-Molina
- Leo Guibas
- Pat Hanrahan
- Scott Klemmer
- Daphne Koller
- David Koslow
- Jean-Claude Latombe
- Marc Levoy
- Chris Manning
- David Mazieras
- Rajeev Motwani
- Serge Plotkin
- Bob Plummer
- Vaughan Pratt
- Tim Roughgarden
- Claire Stager
- Sebastian Thrun
- Jennifer Widom
- Terry Winograd
- Patrick Young
- Russ Altman
- Many additional faculty (email/informal meetings)

Real dedication to undergraduate education

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Systems I: Programming Abstractions

- **CS106B/X**
- Philosophy: *problem solving, basic abstract data types, and recursion*
- General Topics
 - Programming methodology (engineering, modularity, documentation)
 - Algorithmic thinking and problem solving
 - Data abstractions
 - Stacks
 - Queues
 - Linked lists
 - Hash tables
 - Binary trees
 - Generics/templates
 - Recursion
 - Procedural recursion
 - Recursive backtracking
 - Searching and sorting
 - Basic algorithm analysis (big-Oh) and comparison

Systems II: Computer Organization and Systems

- **CS107**, modified with material from CS143 & EE108B
- Philosophy: *From hardware up to the source code*
- General Topics
 - Machine architecture
 - Registers, ALU, CPU, RAM, I/O, basic assembly language
 - Caching, pipelining
 - Memory model
 - Pointers, Heap management, garbage collection
 - Low-level polymorphism and runtime type identification
 - Data representation
 - Facility with C programming as part of topical coverage
 - Compilation
 - Function call mechanics and stack frames
 - Semantic analysis
 - Simple (intermediate) code generation
 - Basic concurrency usage
 - Threading
 - Synchronization, locks and semaphores

Systems III: Principles of Computer Systems

- **CS110** – New course (not replacement for CS140 or CS244A)
- Philosophy: *Building larger scale systems using OS and networking abstractions*
- General Topics
 - Processes
 - Concurrency mechanics on a single processor
 - Context switching, interrupts and exceptions
 - Forking processes, process mechanics and management
 - Interprocess communication
 - Threading
 - Storage and file management
 - File systems
 - Virtual memory and paging
 - Networking
 - Sockets
 - Blocking vs. non-blocking strategies
 - Transport layer: TCP/IP
 - Network layer: names, routing
 - Understanding of distributed systems

Theory I: Mathematical Foundations of Computing

- **CS103** – New course leveraging current CS103A/B/X courses and CS154 (does not replace CS154)
- Philosophy: *Mathematical essentials for CS, with proofs*
- General Topics
 - Logic and proof techniques
 - Prop. and predicate logic (with quantification), formal proof methods
 - Applications: Satisfiability, SAT solving (Putnam-Davis)
 - Induction
 - Formal proofs and applications: program proofs, structural induction
 - Sets, functions, and relations
 - Theory and applications (error-correcting codes, social networks)
 - Intro to formal languages
 - DFAs, NFAs, and Regular Expressions
 - Context-free Grammars
 - Turing machines
 - TMs, TM program, Undecidability and the Halting problem
 - NP-completeness
 - P and NP, examples of NP-complete problems and reductions
 - SAT revisited and Cook's theorem

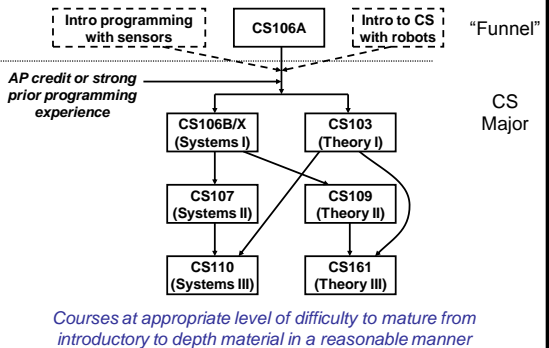
Theory II: Intro. to Probability for Computer Scientists

- **CS109** – New course
 - Replaces Stat116/MS&E120, adds CS applications
- Philosophy: *Probability relevant to CS, with applications*
- General Topics
 - Counting and Combinatorics
 - Combinations, Permutations, Pigeonhole principle
 - Probability theory
 - Random variables and event spaces
 - Conditional probability, independence, conditional independence
 - Distributions: Uniform, Binomial, Multinomial, Normal, Poisson
 - Point estimation, expectation, variance
 - Bayes' Theorem, Law of large numbers, Central Limit Theorem
 - Hypothesis testing
 - Applications: hashing, data analysis, inference
 - Intro. to Machine Learning
 - Hypothesis spaces, learning as search
 - Data fitting, Naive Bayes, Logistic Regression
 - Applications: Email spam filtering, Recommender systems

Theory III: Data Structures and Algorithms

- **CS161** – Modified with some differences in coverage
- Philosophy: *Analysis of data structures and algorithms*
- General Topics
 - Algorithmic complexity and analysis
 - Asymptotics: Big Oh, Omega, and Theta notation
 - Recurrence relations
 - Master theorem
 - Randomization, divide and conquer
 - Introduction to randomized algorithms
 - Quicksort, divide and conquer
 - Heaps and counting sort
 - Hashing
 - Tree and graph definitions and properties, BSTs
 - Greedy Algorithms (including min-cost spanning trees)
 - Dynamic programming
 - Graph algorithms, shortest paths, and applications
 - Blind and heuristic search (A*) in graphs

Prerequisite Structure



Summary of Changes

- Current CS103A/B sequence and STAT116/MS&E120 are replaced as Math requirements with new CS103 and CS109
- CS161 is part of "Theory Core" (remains CS depth course)
- CS154, CS121/221 (and other application course) not in core
- No change in Math units, 10 net units opened in CS depth

- CS106B/X remains an Engineering Fundamental
- CS107 and CS110 are CS depth courses
- CS108, EE108B and Systems electives not in core
- 10 net units opened in CS depth

- Existing electives provide 6 additional units of CS depth
- **Net result:** 26 units opened in CS depth → Track + Electives

Track Structure

- Combination of track requirements and electives satisfies:
 - minimum of 7 courses AND minimum of 26 units
- All tracks have at least 4 (possibly more) required courses
 - Will generally leave room for 2 to 4 elective courses
 - Required senior project is not considered part of track
- Elective courses
 - Set of general CS electives that all students may choose from
 - Additionally, each track specifies *track-specific electives* that may count as elective courses only by students in that track
 - Track-specific electives allow for additional depth or related interdisciplinary course options

Track General Form

- Requirements
 - a) One or two "gateway" courses
 - b) One or two courses from a menu of highly-related courses
 - c) Selection of courses from (b) and/or from a list of more broadly related courses
- Track electives
 - All tracks include "General CS electives" in elective list
 - Additional elective courses available to students in this track
 - Includes non-CS courses and (more) graduate courses in area
- Some tracks do not follow this general form

Initial Set of Tracks Areas

- Artificial Intelligence
- Theory
- Systems
- Human-Computer Interaction
- Graphics
- Information
 - Management and applications of (un)structured information/data
- Biocomputation
- Unspecialized
 - Essentially, the current CS program
- *Individually Designed*

When Do I Have to Choose A Track?

- Do not need to choose a track right after finishing core courses
 - Note that each track has one or two required "gateway" courses
 - These "gateway" courses also count as electives (by design)
- Can sample tracks by taking their "gateway" course
 - If you like the area, you can go further
 - If you don't like the area, the course you took will still count toward your program as an elective (no penalty!)
 - In some cases, you can take gateway course before finishing core
- If you manage to try 4 or 5 areas without finding one you like, you can still graduate under the *unspecialized* track
 - But we really hope you'll find an area you like!

Artificial Intelligence Track

- Requirements
 - a) CS221
 - b) Any two of: CS223A, CS223B, CS224M, CS224N, CS226, CS227, CS228, CS229
 - c) One additional class from category (b) or from the following:
CS205A, CS222, CS224S, CS224U, CS225A, CS225B, CS227B, CS262, CS276, CS277, CS279, CS321, CS326A, CS327A, CS329, CS374, CS379, EE263, EE376A, Eng205, Eng209A, Ling180, MS&E251, MS&E339, MS&E351, Stat315A, Stat315B
- Track electives
 - Courses in categories (b) and (c) above, as well as:
CS270, CS273A, CS274, CS275, CS278, EE364A, EE364B, Econ286, MS&E252, MS&E352, MS&E355, Phil151*, Phil152, Psych202, Psych204A, Psych204B, Stat200, Stat202, Stat205

*students may not count both Phil151 and CS157 toward major requirements.

Theory Track

• Requirements

- CS154
- Any one of: CS164, CS255, CS258, CS261, CS268, CS361A, CS361B, CS365
Note: CS164: *Computing with Physical Objects (new course by Leo Guibas)*
- Two additional classes from category (b) or from the following:
CS143, CS155, CS156, CS157, CS205A, CS228, CS242, CS256, CS259, CS262, CS354, CS355, CS357, CS358, CS359*, CS364A, CS364B, CS369*, CS374, MS&E310

*requires approval of undergraduate advisor.

• Track electives

- Courses in categories (b) and (c) above, as well as:
CME302, CME305, Phil151*, Phil152

*students may not count both Phil151 and CS157 toward major requirements.

Systems Track

• Requirements

- CS140
- One of: CS143 or EE108B
- Two additional courses from category (b) or from the following:
CS144, CS145, CS155, CS240, CS240C, CS240D, CS242, CS243, CS244, CS245, EE271, EE282

• Track electives

- Courses in category (c) above, as well as:
CS240E, CS240X, CS244C, CS244E, CS315A, CS315B, CS343, CS344, CS344E, CS345, CS346, CS347, CS349*, CS448, EE382A, EE382C, EE384A, EE384B, EE384C, EE384S, EE384X, EE384Y

*requires approval of undergraduate advisor.

Human-Computer Interaction Track

• Requirements

- CS147, CS247 (*HCI Foundations*)
- Any one of: CS148, CS248, CS376, CS377, CS378 (*Advanced HCI*)
- Any one of: CS108, CS140, CS221, CS223B, CS229, CS249A (*Buttressing CS*)
- Any one of: Psych55, Psych252, MS&E184, ME101, ME115 (*Designing for People*)

• Track electives

- Courses in categories (b), (c), and (d) above, as well as:
ArtStudi60, Comm269, CME340, CS447*, CS448B*, Ling180, EE118, MS&E216A, Psych205, Psych221

*requires approval of undergraduate advisor.

Graphics Track

• Requirements

- CS248
(Starting in AY 09-10, CS148 and CS248 will both be required as a two course sequence)
- Any one of: CS205A, CME104, CME108, Math52, Math113
(Of the choices above, CS205A is strongly recommended as a preferred choice)
- Any two of: CS164, CS178, CS205B, CS223B, CS268, CS348A, CS348B, CS448
Note: CS164: *Computing with Physical Objects (new course by Leo Guibas)*
CS178: *Digital Photography (new course by Marc Levoy)*

• Track electives

- Courses in category (c) above, as well as:
ArtStudi60, ArtStudi70, ArtStudi179, CS48N, CS277, CS326A, CME302, CME306, CME324, EE262, EE264, EE278, EE368, ME101, Psych30, Psych221, STS144

Information Track

• Requirements

- CS124, CS145
Note: CS124: *From Languages to Information (new course by Dan Jurafsky and Chris Manning)*
- Two courses, which must be from *different* areas below:
 - Information-based AI Applications*
CS224N, CS224S, CS229
 - Database and Information Systems*
CS140, CS240D, CS245, CS345A, CS345C, CS346, CS347
 - Information Systems in Biology*
CS262, CS270, CS274
 - Information Systems on the Web*
CS276, CS364B, <<Future course on Internet Algorithms by Rajeev Motwani>

• Track electives

- Courses in category (b) may also be counted as electives

Biocomputation Track

• Requirements (More CS oriented version of BMC Informatics Track)

- Mathematics: (1 course less than CS)
 - Math 41, Math 42, CS103 (Theory I), CS109 (Theory II)
 - One of: Stat141, Stat203, Stat205, Stat215, Stat225
- Science: (2-3 courses more than CS)
 - Physics 41, Chem 31A/B or 31X, Chem 33
 - Bio41, 42 or HumBio2A, 3A,
- Engineering Fundamentals: (1 course less than CS)
 - CS106B/X (Systems I)
 - Elective
- Additional CS Core: (same as CS)
 - CS107 (Systems II), CS110 (Systems III), CS161 (Theory III).
- Biocomputation Track: (10-11 units)
 - Any one of: CS121, CS221, CS228, CS229, CS223B
 - Any one of: CS270, CS273A, CS274, CS275, CS278, CS279, CS282
 - One additional course from (a) or (b) or the following: CS145, CS147, CS148 or CS248
- Four Biocomputation Electives: (12-13 units; Different than CS electives)
 - One course from either general CS of BMC Informatics elective lists
 - One course from BMC Informatics elective list
 - One course from either BMC Informatics, Cell/Mol, or Organs elective lists
 - One course from either BMC Cell/Mol or Organs elective lists
- Senior Project, Technology in Society and Writing in Major (same as CS)
- Total:** 93-99 units versus 93 units for Standard CS Track

Unspecialized Track

- Requirements
 - CS154
 - Any one of: CS140, CS143
 - One additional class from category (b) or from the following: EE108B, CS144, CS155, CS240D, CS242, CS244
 - Any one of: CS121 or CS221, CS223A, CS223B, CS228, CS229
 - Any one of: CS145, CS147, CS148 or CS248, CS262
- This is basically our current curriculum
 - Adapted to fit into new track structure
 - Some additional options for AI courses
- Allows “in-flight” students to graduate under new program

Individually Designed Track

- Students may propose Individually Designed Track
- Must be an intellectually coherent program of study
 - Proposal should justify program and why it cannot be satisfied via an existing track
- Must specify equivalent of track and electives
 - Minimum of 7 courses; at least 4 must be CS courses numbered 100 or above
 - Each course must be taken for a minimum of 3 units
 - Minimum of 26 total units for track + electives
- Proposal must be approved by undergraduate advisor and Associate Chair
 - Approvals must be obtained at least 2 quarters prior to completion of program
- Proposal cannot modify any non-track/elective requirements
 - E.g., SoE requirements (Math, Science, Eng Fundamentals) cannot be modified
 - Must include all CS Core courses

General CS Electives

- CS108, CS121 or CS221*, CS124, CS140, CS142, CS143, CS144, CS145, CS147, CS148 or CS248*, CS154, CS155, CS156, CS157, CS164, CS205A, CS205B, CS222, CS223A, CS223B, CS224M, CS224N, CS224S, CS224U, CS225A, CS225B, CS226, CS227, CS228, CS228T, CS229, CS240, CS242, CS243, CS244, CS244B, CS245, CS247, CS249A, CS249B, CS255, CS256, CS257, CS258, CS261, CS262, CS270, CS271, CS272, CS273A, CS274, CS276, CS277, CS295, CME108, EE108B, EE282
- *Students may not count both CS121 and CS221, or both CS148 and CS248 toward their major requirements.
- Very similar to our current set of electives
 - Added courses that are no longer required in major (e.g., CS108, CS121/221)
 - Added some newly proposed undergraduate courses (e.g., CS124, CS142, CS164)

Unit Calculations

- Core (29 units)
 - Theory: CS103 (5), CS109 (5), CS161 (4) = 14 units
 - Systems: CS106B/X (5), CS107 (5), CS110 (5) = 15 units
- Upper division (29 units)
 - Track: 4-5 courses
 - Electives: 2-4 courses
 - Capstone: 3 units

Minimum of 7 courses (at least 26 units)
- Total related units = 58 units (same as before)
 - 10 units: Mathematics (CS103, CS109) (same as before)
 - 5 units: Eng. Fundamentals (CS106B/X) (same as before)
- Total CS depth units = 43 units (same as before)

Curriculum Comparison

Old		New	
Programming:	3 courses	Systems core:	3 courses
Theory: (2 + 2 depth):	4 courses	Theory core:	3 courses
Systems depth:	3 courses	Track (depth):	4-5 courses
Applications:	2 courses	Electives:	2-4 courses
Electives:	2 courses	Capstone:	1 course
Capstone:	1 course		
TOTAL:	15 courses	TOTAL:	14-15 courses

Same number of CS units in both cases.

Science, Engineering Fundamentals, WIM requirements unchanged.

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Course Transition Plan in 2008-09

Fall	Winter	Spring
CS106X (Systems I)	CS106B (Systems I)	CS106B/X (Systems I)
CS107 (last old version)		CS107 (new Systems II)
		CS110 (Systems III)
CS103A	CS103B	
	CS103 (Theory I)	CS109 (Theory II)
CS161 (current)	CS161 (current)	

- Existing CS103A/B sequence offered one last time
- Students having taken old CS107 can take CS110
- Content of CS161 will transition (slightly) in 2009-10

What If I'm Already Part-way Through?

- Students can graduate under any curricular requirements since they entered Stanford
 - You can choose to graduate under old or new CS requirements
- What if I've already taken the lower-division courses?
 - We have a set of "course equivalences" to allow you to graduate under new requirements, if you like
- What if I've already taken most upper-division courses?
 - If you only have a couple courses left in your program, it may be easier to just complete the old requirements
 - If you have not yet taken many upper-division course, you may find the new curriculum an attractive option

Course Equivalences

- CS106B/X Same course
- CS107 Current CS107 satisfies new CS107
- CS110 If you've taken CS108 and (CS140 or CS143) *prior to Spring 08-09*, CS108 will satisfy CS110 (but you'll need 1 extra unit in track + electives)
If you've taken CS108, but not (CS140 or CS143) *prior to Spring 08-09*, can count CS108 as elective, but still need to satisfy CS110 requirement
- CS103 CS103A/B or CS103X satisfies new CS103. If you took CS103X you'll need 1 additional unit in track + electives
- CS109 Stat116 (or equivalent) taken *prior to Spring 2008-09* satisfies CS109
- CS161 Current CS161 satisfies requirement

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References on the New Curriculum

- 2008-2009 Stanford Bulletin contains complete details on new CS program requirements
- 2008-2009 Handbook for Undergraduate Engineering Programs has program sheets (one sheet per track)
 - Program sheets also available on-line from CS website:
<http://cs.stanford.edu/degrees/undergrad/ProgramSheets.shtml>
- These slides will also be posted on CS undergraduate education web page:
<http://cs.stanford.edu/degrees/undergrad/>

People to Know/Ask

- Jeffrey Spehar, CS Course Advisor
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- Claire Stager, Student Services Manager
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- Mehran Sahami, Associate Chair for Education
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Thank you for your attention

Questions?