



Computer Science and Engineering Undergraduate Program Overview

Sharon ONeal

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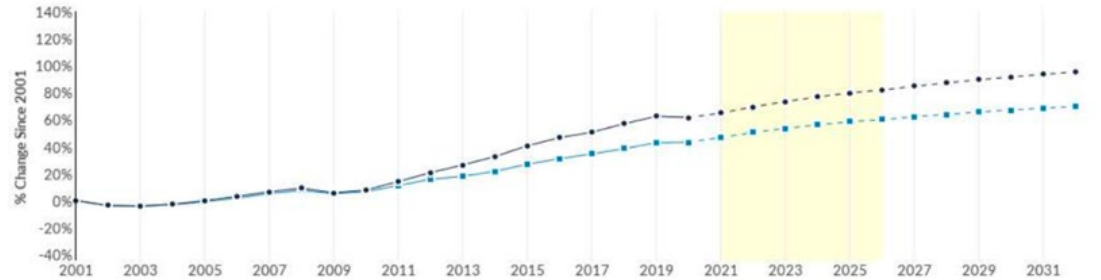
Computer Science and Engineering Degree Objectives

- *MEET THE INCREASING INDUSTRY DEMANDS FOR HIGHLY SKILLED SOFTWARE/COMPUTING TALENT*
- Develop a 120-unit ABET accredited Computer Science and Engineering degree program to begin in 2023/2024
 - Accreditation thru ABET's **Computing Accreditation Commission (CAC)** and/or the **Engineering Accreditation Council (EAC)**
 - Targeting a Fall 2023 start for the BS degree
- Separate proposals have been developed include for MS and PhD in CSE in 2024/2025
- Serve local, state, and national increasing needs in engineering computing talent related to economic development and national security
 - Aligned with Arizona's New Economic Initiative
- Support and enable the university's growth goals / initiatives
 - Increase student enrollments
 - Increase research opportunities and collaborations



Workforce Demands Continue to Go Unmet for SW and Computing Professionals

- The market demand for those trained in engineering computing disciplines is projected to have significant growth in both the near- and long-term futures.
- The growth in computing-related jobs up to 2021 regionally and nationally (see graph to right)
- The BS CSE program will serve both local, state, and national needs related to employment, economic development, and national security.
 - *Among the most important in support of the ongoing fourth industrial revolution and in close alignment with Arizona's New Economy Initiative.*

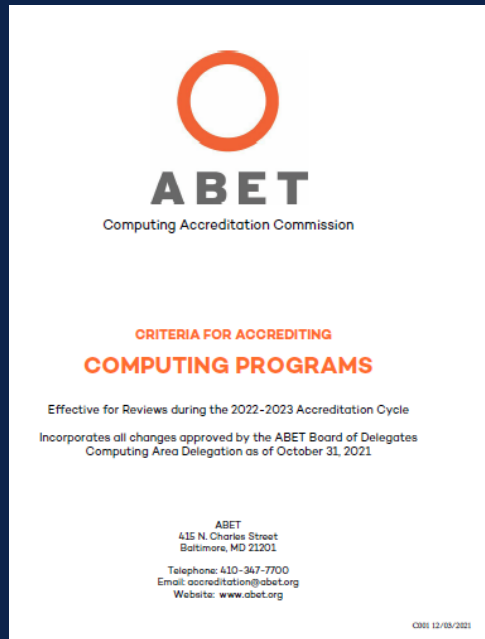


| Region | 2021 Jobs | 2026 Jobs | Change | % Change |
|----------|-----------|-----------|---------|----------|
| ● Region | 1,010,147 | 1,115,128 | 104,981 | 10.4% |
| ■ Nation | 5,406,515 | 5,892,114 | 485,599 | 9.0% |

**Summary of AAU Universities with
Computer Science and Computer Science and Engineering Degree Programs
in Different Colleges (including Engineering)**

| Peer / AAU | University | College | Degree Type | Degree Name | Accreditation | Min. Units | Total Enrollment (2020)** |
|------------|---|---|-------------|---|------------------------------------|------------|---------------------------|
| AAU | University of California - Berkeley | College of Engineering | BS | Electrical Engineering and Computer Science (EECS) | <i>Unclear (ABET through 2019)</i> | 120 | 1519 |
| | | College of Letters and Science | BA | Computer Science | None | 119 | 1465 |
| Peer / AAU | University of California - Davis | College of Engineering | BS | Computer Science and Engineering | EAC - 1987 CAC - 1995 | 144 | 349 |
| | | College of Letters and Science | BS | Computer Science | None | 144? | 931 |
| Peer / AAU | University of California - Los Angeles | Henry Samueli School of Engineering and Applied Science | BS | Computer Science | Claims to be EAC and CAC | | |
| | | Henry Samueli School of Engineering and Applied Science | BS | Computer Science and Engineering | CAC and EAC Accredited | | |
| Peer / AAU | University of Florida | Herbert Wertheim College of Engineering | BS | Computer Science (EG-CSE) | None | 120 | 758 |
| | | College of Liberal Arts and Sciences | BS | Computer Science (CSC) | None | 120 | 464 |
| Peer / AAU | University of Illinois - Urbana-Champaign | Grainger College of Engineering | BS | Computer Science | CAC - 2000 | 128 | 2001 |
| | | Grainger College of Engineering | BS | Mathematics and Computer Science | <i>UNK</i> | 120 | <i>UNK</i> |
| | | Grainger College of Engineering | BS | Statistics and Computer Science | <i>UNK</i> | 120 | <i>UNK</i> |
| | | College of Liberal Arts and Sciences | BS | CS + X Programs (where X = several different disciplines) | None | 120 | <i>UNK</i> |
| Peer / AAU | University of Iowa | College of Liberal Arts and Sciences | BA | Computer Science | None | 120 | <i>UNK</i> |
| | | College of Liberal Arts and Sciences | BS | Computer Science | None | 126 | <i>UNK</i> |
| | | Dual Program: CLAS & Engineering | BSE | Computer Science and Engineering | EAC - 2018 CAC - 2018 | 129 | <i>UNK</i> |
| AAU | University of Michigan | College of Engineering | BSE | Data Science | CAC - 2002 | 128 | 100 |
| | | College of Engineering | BSE | Computer Science | CAC - 2002 | 128 | 1261 |
| | | College of Literature, Science and the Arts | BS | Computer Science | None | 120 | 542 |
| Peer / AAU | The Ohio State University | College of Engineering | BS | Computer Science and Engineering | CAC - 1998 EAC - 1998 | 126 | 1754 |
| | | College of Engineering | BA | Computer and Information Science | None | 122 | 617 |
| | | College of Engineering | BS | Computer and Information Science | None | 124 | |
| Peer / AAU | University of Minnesota - Twin Cities | College of Science and Engineering | BS | Computer Science | None | 120 | 1104 |
| | | College of Liberal Arts and Sciences | BA | Computer Science | None | 120 | <i>UNK</i> |

ABET CAC Accreditation Curriculum Criteria (Criterion 5)



| Units | Description |
|---|--|
| Basic requirements (30) | <i>Up-to-date coverage of fundamental and advanced computing topics that provide breadth and depth in computing (included in the 40 units below)</i> |
| Computer Science Specific Requirements (40) | <ul style="list-style-type: none">• Algorithms and complexity, CS theory, programming languages and software development• Substantial coverage of at least one general purpose programming language• Computer architecture and organization, information management, networking and communications, operating systems and parallel and distributed computing• Computing based systems• A major project requiring integration and application of knowledge and skills |
| 15 | Mathematics including discrete mathematics and at least equivalent to introductory calculus |
| 6 | Natural science intended for science and engineering majors. Must include lab work. |

Summary Comparison of Peer Institutions with CS and CSE Degree Programs

***Many courses are duplicated across
the CS and CSE programs***

CAC/EAC accredited programs:

- Include more advanced math, physics or natural science courses
- More prescriptive and more “required” courses (less electives)
- More interdisciplinary focus
- Require a major capstone course
- Software application/product focus

Non-accredited programs:

- Give the student more options / flexibility in coursework and electives
- Some are more theory-based
- Broader focus across diverse liberal arts and sciences
- Some have fewer total degree units required

Side by Side Curriculum Comparison - CSE to CSC

| Computer Science and Engineering BS Degree = 120 units | | | |
|--|---|-----------|--------------|
| Course Number | Course Name | Units | New / Exists |
| Similar or Equivalent Courses | | | |
| GenEd | General Education Courses | | |
| CSE 101 | Programming I | 4 | N |
| ENGL 101 | English Composition I | 3 | E |
| ENGL 102 | English Composition II | 3 | E |
| MATH 122A/B | Calculus I | 5 | E |
| MATH 129 | Calculus II | 3 | E |
| CSE 201 | Programming II | 3 | N |
| Science | Natural Science / Lab | 4 | E |
| Science | Exploring Perspectives Natural Science #2 | 3 | E |
| CSE 303 | Fundamentals of Computer Architectures | 3 | N |
| CSC 355 | Analysis of Discrete Structures (for Engr) | 3 | E |
| General Electives | General Electives (could be used for Minor) | 18 | E |
| Different Courses (Additional Math or Interdisciplinary Engr Focused) | | | |
| ENGR 102 | Intro to Engineering | 3 | E |
| MATH 243 | Discrete Math | 3 | E |
| ECE 274A | Digital Logic | 4 | E |
| SIE 305 | Intro to Engineering Probability and Statistics | 3 | E |
| CSE 301 | Data Management | 3 | N |
| SFWE 302 | Software Architecture and Design | 3 | E |
| MATH | Math Elective | 3 | E |
| CSE 302 | Theory of Computation | 3 | N |
| CSE 401 | Operating System Design | 3 | N |
| ECE 311 | Engineering Ethics | 1 | E |
| ENGR 498 A | Interdisciplinary Capstone I | 3 | E |
| SFWE 402 | Software DevSecOps | 4 | E |
| ENGR 498B | Interdisciplinary Capstone II | 3 | E |
| UD Computing Elective | Upper Division Computing Electives | 9 | E |
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|---|--|-----------|--------------|
| Course Number | Course Name | Units | New / Exists |
| Similar or Equivalent Courses | | | |
| GenEd | General Education Courses | | |
| CSC 110 | Intro to Computer Programming I | 4 | E |
| ENGL 101 | English Composition | 3 | E |
| ENGL 102 | English Composition II | 3 | E |
| MATH 122 A/B | Calculus I | 5 | E |
| MATH 129 | Calculus II | 3 | E |
| CSC 120 | Intro to Computer Programming II | 4 | E |
| Science | Supporting Science #1 | 4 | E |
| Science | Supporting Science #2 | 4 | E |
| CSC 252 | Computer Organization | 3 | E |
| CSC 345 | Analysis of Discrete Structures | 3 | E |
| Electives | Other Electives (choose 4) | 12 | E |
| Different Courses (Traditional Comp Sci) | | | |
| MATH 120R | Pre-Calculus | 4 | E |
| Language | 1st Semester Second Language | 4 | E |
| Language | 2nd Semester Second Language | 4 | E |
| CSC 210 | Software Development | 4 | E |
| CSC 245 | Intro to Discrete Structures | 3 | E |
| CSC 335 | Object Oriented Programming | 3 | E |
| CSC 352 | Systems Programming & Unix | 3 | E |
| CSC 335 | Object Oriented Programming | 3 | E |
| CSC Paradigms | CSC Paradigm Elective (Choose 1) | | E |
| CSC 372 | Comparative Programming Languages | 3 | E |
| CSC 422 | Intro to Parallel and Distributed Programming | | E |
| CSC 460 | Database Design | | E |
| CSC T&W | CSC Theory and Writing Elective (Choose 1) | | E |
| CSC 455 | Algorithms | 3 | E |
| CSC 450 | Algorithms in Bioinformatics | | E |
| CSC 473 | Automata, Grammars, & Languages | | E |
| CSC Sys | CSC Systems Elective (Choose 1) | | E |
| CSC 452 | Principles of Operating Systems | 3 | E |
| CSC 453 | Compilers and System Software | | E |
| Electives | Upper Division Electives - CSC 3XX or 4xx (Choose 3) | 9 | E |

Other Universities with
ABET / CAC /EAC
Accredited
CS or CSE Programs

AAU Member:

- University of California Los Angeles
- University of Colorado
- Michigan State University
- Texas A&M University

Non-AAU Member:

- University of Alabama
- Arizona State University
- Northern Arizona University



Collaboration Memo Signed by CoS and ENGR



1/20/2023

Prof. Greg Heileman
Vice Provost for Undergraduate Education

Re: Collaborations between COS and COE on BS-CSE degree

Dear Greg,

As you are aware, the College of Engineering (COE) is developing a BS - **Computer Science and Engineering** (CSE) program to be housed in the Department of Electrical and Computer Engineering (ECE). The proposed program has a firm engineering foundation that is ABET CAC/EAC compliant. It aims to broaden the University of Arizona's workforce development pipeline in direct response to industry needs and to provide a unique opportunity for students to develop knowledge of computer science and engineering by combining theory-based concepts with advanced engineering technologies and pedagogy to create solutions that address the grand challenges of the 21st century and beyond.

We are grateful to our colleagues, Prof. Christian ~~Collberg~~ serving as head of the department of Computer Science and Prof. Michael Wu serving as head of Electrical and Computer Engineering, for leading in depth discussions on how best we can maximize the synergy between the proposed new BS-CSE program in COE and the existing BS-Computer Science (BS-CS) program in the College of Science (COS). Below we summarize the planned collaborations and interactions between the two degree programs.

Introductory Programming

CSE students will be required to take two introductory programming classes. They can choose either:

- (1) CSC 110 *Introduction to Computer Programming I* and CSC 120 *Introduction to Computer Programming II*, or,
- (2) CSE 101 *Programming I* and CSE 201 *Programming II*.

A student can also choose to take CSC 110 and then CSE 201 or CSE 101 and then CSC 120, upon approval of the instructors.

Computer Organization

CS students are currently required to take CSC 252 *Computer Organization*. We plan to replace this with ECE 369 *Fundamentals of Computer Architecture*, or possibly a new course, CSE 303 *Fundamentals of Computer Architecture*, to minimize duplication.

Data Structures

We plan to collaborate to develop new upper-division data structures courses, CSC 345 *Analysis of Discrete Structures* (for CS students) and CSC 355 *Analysis of Discrete Structures* (for CSE students). The primary difference between these courses will be the coding language prerequisites: CSC 345 assumes Java (from CSC 210), while CSC 355 assumes C (from ECE 275). It may be preferable to have two sections of a single course since this could make it simpler to keep their course contents synced.

Ethics

We will require CS students to take ECE 311 *Engineering Ethics*. Currently, this is a 1-unit course. We aim to explore the possibility of expanding this into a 3-unit course.

400-level Electives

Open the following CS classes to ECE students:

- CSC 452 *Principles of Operating Systems*
- CSC 453 *Compilers and System Software*
- CSC 445 *Algorithms*
- CSC 473 *Automata, Grammars, and Languages*

Web Development and Internet of Things

We believe it would be valuable for CS students to be exposed to topics on embedded systems. The nearest course for this is ECE 413 *Web Development and the Internet of Things*. However, the content of this course is divided between Web Development and Embedded Systems, and we share a concern is that there may not be enough time to go into depth on either topic. To address these issues, we aim to explore the possibility of opening CSC 337 *Web Programming*, to ECE students, and focusing ECE 413 on embedded systems topics.

Future course development

CS and ECE agree to discuss the development of new courses open to both sets of students.

Depending on faculty interest, these courses could be owned either by ECE or CS. Examples of topics that would be of high interest and value to both sets of students, including, but not limited to:

- Cryptography
- Robotics
- Software testing
- Program verification
- Functional programming
- Quantum computation
- High-performance computing
- Information privacy
- Computer algebra

Thank you also for your guidance and leadership as we have developed this proposal. We ask that you circulate this summary to all and any committees who are interested, as the proposal is advanced for review and approval.

Regards,

Carmela Garziona

Dean Garziona

Jan. 31, 2023

Date

Dean Hahn

Dean Hahn

Jan. 22, 2023

Date

Cc: Michael, Christian, Assoc deans, Liesl, etc.

Debate Over Name of the Degree Program

Per email from Jim Baygents (2/13):

- *In choosing a name, we are constrained somewhat by the meaning of computer engineering, which is a degree/discipline accredited by the Engineering Accreditation Commission of ABET.*
- *Computer Engineering is closely coupled to Electrical Engineering (Computer and Electrical are lumped together under the same program criteria ... and we offer a BS Electrical & Computer Engineering).*
- *Computer Science degrees (that is, degrees containing the name Computer Science) are accredited by the Computing Accreditation Commission of ABET. The EAC and the CAC specify different student outcomes.*

Five AAU-Public schools offer bachelor's degrees named "Computer Science and Engineering"

- Ohio State
- University of Iowa
- UC, Davis
- UC, Irvine
- UCLA

Four of these five are UA peers. Another eight schools (not AAU-P) offer bachelor's degrees named "Computer Science and Engineering", viz.

- Bucknell
- MIT
- Santa Clara
- University of Toledo
- UC, Merced
- Connecticut
- Louisville
- Nevada, Reno



General Education (29 units)

- UNIV 101 - Introduction to Gen-Ed Experience (1 unit)
- Foundations - ENGL 101 and ENGL 102 - English Composition I and II (6 units)
- Foundations – MATH 129 (3 units)
- Exploring Perspectives – Artist (3 units)
- Exploring Perspectives – Humanist (3 units)
- Exploring Perspectives – Social Scientist (3 units)
- Exploring Perspectives – Natural Scientist (3 units)
- Building Connections – (9 units)
- UNIV 301 - General Education Portfolio (1 unit)

Major Core (46 units)

- ENGR 102 A/B - Introduction to Engineering (3 units)
- CSE 101 – Programming I (4 units) **NEW**
- CSE 201 – Programming II (3 units) **NEW**
- ECE 274A – Digital Logic (4 units)
- CSE 301 Data Management (3 units) **NEW**
- SIE 305 – Engineering Probability and Statistics (3 units)
- CSE 302 – Theory of Computation (3 units) **NEW**
- CSE 303 – Fundamentals of Computer Architecture (3 units) **NEW**
- ECE 311 – Engineering Ethics (1 unit)
- SFWE 302 – Software Architecture and Design (3 units)
- CSC 355 – Data Structures and Algorithms (3 units)
- SFWE 402 – Software DevSecOps (4 units)
- CSE 401 – Operating System Design (3 units) **NEW**
- ENGR 498A/B – Interdisciplinary Capstone (6 units)

Math and Sciences (18 units)

- MATH 122 A/B - Calculus I (5 units)
- MATH 129 – Calculus II (included in GenEd Foundations) (3 units)
- Math 243 – Discrete Math (3 units)
- MATH Elective (Linear Algebra, Number Theory, Numerical Methods, or Vector Calculus) (3 units)
- Lab Science (4 units)

Computing Electives (9 units)

Select 9 units of UD computing technical electives from other Engineering courses (i.e. ECE, SIE, or other applicable engineering courses), CSC or ISOC. See major advisor for course approval.

A preliminary list of acceptable UD technical computing electives include:

- ECE 330B Computational Techniques
- ECE 373 Object-Oriented Software Design
- ECE 413 Web Development and Internet of Things
- ECE 466 Knowledge System Engineering
- SFWE 301 Software Requirements Analysis and Test
- SFWE 401 Software Assurance
- SFWE 403 Software Project Management
- SIE 370 Embedded Computer Systems
- SIE 431 Simulation Modeling and Analysis

General Electives (18 units)



Projected Enrollments and New Resources Needed (BS level only)

- IV. **Projected Enrollment for the First Five Years:** The projected enrollment in the Computer Science Engineering BS degree program across all campuses is shown in the table below (*note that the projections are extended to a 5-year period to be consistent with the extended financial analysis timeframe*). The basis for these projections was derived by comparing enrollments at other AAU universities that have a dual Computer Science program in both their College of Engineering (or similar) and another college.

| Degree | Year 1 (2023 / 2024) | Year 2 (2024 / 2025) | Year 3 (2025 / 2026) | Year 4 (2026 / 2027) | Year 5 (2027 / 2028) |
|--------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| BS | 60 | 140 | 300 | 425 | 500 |

| Projected Additional Resource Acquisition Plan (by Year) (On Campus + Online) | | | | | | |
|---|-------------|-------------|-------------|-------------|-------------|---|
| Resource Type | 2023 - 2024 | 2024 - 2025 | 2025 - 2026 | 2026 - 2027 | 2027 - 2028 | Total New Instructors Acquired Over 5 Years |
| Tenured Track Faculty | 4 | 2 | 2 | 2 | 0 | 10 |
| PoP (On Campus) | 1 | 0 | 0 | 0 | 0 | 1 |
| Professor of Practice (Online) | 0 | 0 | 1 | 1 | 0 | 2 |
| Adjunct (On Campus) | 0 | 0 | 1 | 1 | 0 | 2 |
| Adjunct (Online) | 0 | 0 | 1 | 0 | 0 | 1 |



Backup Information



New Courses Required

V. **NEW COURSES NEEDED** – using the table below, list any new courses that must be created for the proposed program. If the specific course number is undetermined, please provide level (i.e., CHEM 4XX). Add rows as needed.

| Course prefix and number (include cross-listings) | Units | Title | Pre-requisites | Modes of delivery (online, in-person, hybrid) | Status* | Anticipated first term offered | Typically Offered (F, W, Sp, Su) | Dept signed party to proposal? (Yes/No) | Faculty members available to teach the courses |
|---|-------|---------------------------------------|---------------------|---|---------|--------------------------------|----------------------------------|---|--|
| CSE 101 | 4 | Programming I | None | online, in-person | D | Spring 2024 | F, Sp | Yes | Dr Diana Saldana |
| CSE 201 | 3 | Programming II | CSE 101 | online, in-person | D | Fall 2024 | F, Sp | Yes | Dr Diana Saldana |
| CSE 301 | 3 | Data Management | CSE 201 | online, in-person | D | Spring 2025 | Sp | Yes | TBR (New Faculty) |
| CSE 302 | 3 | Theory of Computation | Math 243 | online, in-person | D | Fall 2025 | F | Yes | TBR (New Faculty) |
| CSE 303 | 3 | Fundamentals of Computer Architecture | ECE 274A | online, in-person | D | Fall 2025 | F | Yes | TBR (New Faculty) |
| CSE 401 | 3 | Operating Systems | CSE 201 and CSE 303 | online, in-person | D | Spring 2026 | Sp | Yes | TBR (New Faculty) |

*In development (D); submitted for approval (S); approved (A)



Sample 4 Year Plan

| Semester 1 | | Semester 2 | | Semester 3 | | Semester 4 | |
|--|-------|--------------------------|-------|------------------------------|-------|--------------------------|-------|
| Course prefix and number | Units | Course prefix and number | Units | Course prefix and number | Units | Course prefix and number | Units |
| ENGL 101 | 3 | ENGL 102 | 3 | MATH 243 | 3 | SIE 305 | 3 |
| ENGR 102 | 3 | MATH 129 | 3 | CSE 201 | 3 | CSE 301 | 3 |
| MATH 122 A/B | 5 | CSE 101 | 4 | ECE 274A | 4 | CSC 355 | 3 |
| Gen-Ed (<u>Expl Persp (EP) Artist</u>) | 3 | Science Natural w/Lab | 4 | Gen-Ed (EP Humanist) | 3 | SFWE 302 | 3 |
| UNIV 101 | 1 | | | Gen-Ed (EP Social Scientist) | 3 | MATH 313 or MATH 315 | 3 |
| Total | 15 | Total | 14 | Total | 16 | Total | 15 |

| Semester 5 | | Semester 6 | | Semester 7 | | Semester 8 | |
|-------------------------------|-------|-------------------------------|-------|-------------------------------|-------|-------------------------------|-------|
| Course prefix and number | Units | Course prefix and number | Units | Course prefix and number | Units | Course prefix and number | Units |
| CSE 302 | 3 | CSE 401 | 3 | ENGR 498A | 3 | ENGR 498B | 3 |
| CSE 303 | 3 | UD Computing Elective 1 | 3 | SFWE 402 | 4 | UD Computing Elective 3 | 3 |
| General Elective 1 | 3 | General Elective 3 | 3 | UD Computing Elective 2 | 3 | General Elective 5 | 3 |
| General Elective 2 | 3 | General Elective 4 | 3 | UNIV 301 | 1 | General Elective 6 | 3 |
| Gen-Ed (EP Natural Scientist) | 3 | Gen-Ed (Building Connections) | 3 | Gen-Ed (Building Connections) | 3 | Gen-Ed (Building Connections) | 3 |
| | | ECE 311 | 1 | | | | |
| Total | 15 | Total | 16 | Total | 14 | Total | 15 |



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CoS Collaboration Agreement Summary (2 of 3)

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- Quantum Computation
- High-Performance Computing
- Information Privacy