THE UNIVERSITY OF ARIZONA

New Academic Program Workflow Form

General

Proposed Name: Comp Science and Engineering

Transaction Nbr: 00000000000163

Plan Type: Major

Academic Career: Graduate

Degree Offered: Doctor of Philosophy

Do you want to offer a minor? N

Anticipated 1st Admission Term: Fall 2024

Details

Department(s):

ENGR

DEPTMNT ID	DEPARTMENT NAME	HOST
2303	Electrical & Computer Engineering	Y

Campus(es):

MAIN

LOCATION	DESCRIPTION
TUCSON	Tucson

Admission application terms for this plan: Spring: Y Summer: Y Fall: Y

Plan admission types:

Freshman: N Transfer: Y Readmit: Y Graduate: Y

Non Degree Certificate (UCRT only): N

Other (For Community Campus specifics): N

Plan Taxonomy: 11.0701, Computer Science.

Program Length Type: Program Length Value: 0.00

Report as NSC Program:

SULA Special Program:

Print Option:

Diploma: Y Doctor of Philosophy Computer Science and Engineering

Transcript: Y Doctor of Philosophy Computer Science and Engineering

Conditions for Admission/Declaration for this Major:

The minimum admission requirements for the Ph.D. program are as follows:

- Admission to the Post-M.S. Option requires a master's degree in Engineering, Math, Physics, Computer Science, or Optics.
- Admission to the Direct Option requires a bachelor's degree in Engineering, Math, Physics, Computer Science, or Optics. An exceptional record is required for admission into the Ph.D. Direct Option. This option is not available to students who have already completed at least one semester under the UA ECE master's program. This option is not available to students who have already completed a master's degree in Engineering, Math, Physics, Computer Science, or Optics.
- Minimum GPA of 3.0.
- Students who do not have a degree equivalent to the UA Bachelor of Science degree in Electrical & Computer Engineering may be admitted into the graduate ECE program but may be required to complete some courses prior to enrolling in specific graduate courses.

Requirements for Accreditation:

N/A

Program Comparisons

University Appropriateness

Two of the College of Engineering's strategic pillars are:

1) Driving student success for a rapidly changing world, and
2) Tackling critical problems at the edges of human endeavor

The new Computer Science and Engineering MS and PhD degree programs play a critical role in both pillars. The students graduating with an MS or PhD in Computer Science and Engineering degree will be better positioned to develop the skills and mindsets to be leaders in the areas of computing machine learning, ever-increasing automation and connectivity, human and intelligent systems, data science, quantum information engineering, and network sciences.

By offering competitive, relevant, and experiential-based learning to prospective

students, the proposed program has the potential to build a strong pipeline for undergraduate and graduate education in Computer Science and Engineering. It will contribute to the much-needed workforce development to close the talent gap in computing and expand the ability to grow research programs that are attractive to forthcoming undergraduate and graduate students. To support the proposed program, we will recruit faculty who can significantly impact computing areas of research and education. These faculty will pursue externally funded, competitive research to advance the state-of-the-art in applied computer science in engineering and integrate their research into the curricula. The broader impacts of these faculty will ultimately lead to a nationally recognized computer science and engineering program at the University of Arizona. It is also anticipated to catalyze collaboration and strengthen the existing electrical and computer engineering program and other engineering disciplines in the College.

Another goal of offering the Computer Science and Engineering degrees is to increase the number of female and other underrepresented students in the College of Engineering by leveraging Broaden Participation in Computing (BPC) ¿ a national initiative by the Computing Research Association with support from the National Science Foundation's (NSF) Directorate for Computer and Information Science and Engineering (CISE). Additional features and programs that contribute to enhancing student success and increasing diversity and inclusion will be included in the support infrastructure for the degrees, aiming to foster academic cultures that are more inclusive of non-dominant identities and infuse policy-driven, identity-inclusive strategies throughout the entire program.

Arizona University System

NBR	PROGRAM	DEGREE	#STDNTS	LOCATION	ACCRDT
1	Computer Science	PHD	42	University of Arizona - Main	N
2	Computer Science	PHD	150	Arizona State University	N
3	Information and Computing	PHD	35	Northern Arizona University	N

Peer Comparison

See attached document summarizing the PhD programs at the University of Florida and University of Michigan.

Resources

Library

Acquisitions Needed:

None

Physical Facilities & Equipment

Existing Physical Facilities:

Office and laboratory space will be required for new faculty. It is currently anticipated that for the first 3 years of the program, the new facilities required can be accommodated in the current Electrical and Computer Engineering building.

Additional Facilities Required & Anticipated:

New laboratory equipment needed for Tenure Track faculty is included in estimated start-up packages and will vary depending on the nature of the research for acquired new faculty members.

Other Support

Other Support Currently Available:

The College of ENGR and ECE Dept is currently well structured and to be able to accommodate the new program, including IT support. Additional staff will be required and described below.

Other Support Needed over the Next Three Years:

None

Comments During Approval Process

3/26/2023 3:19 PM

MHWU

Comments
Approved.

11/8/2023 9:38 AM

ESANDMAR

Comments
Uploaded new copies of the additional info form as well as peer comparison.

11/8/2023 9:38 AM

ESANDMAR

Comments
Approved.

THE UNIVERSITY OF ARIZONA

NEW ACADEMIC PROGRAM – MAJOR
Preliminary Proposal Form

I. **Program Details**

a. **Name (and Degree Type) of Proposed Academic Program:** PhD Computer Science and Engineering (CSE)

i. **Emphases (if applicable):** None

b. **Academic Unit(s)/College(s):**

College of Engineering:
2303 - Electrical and Computer Engineering

c. **Campus/Location(s):** Main campus only

d. **First Admission Term:** Fall 2024

e. **Primary Contact and Email:** Sharon ONeal sharononeal@arizona.edu

II. **Executive Summary:**

Develop a Computer Science and Engineering (CSE) PhD program with a planned Fall 2024 start date.

- Provides an interdisciplinary engineering curriculum in closely related computing fields (computer science, software engineering, and computer engineering)
- Serve local, state, and national increasing needs in engineering computing talent related to economic development and national security
    a. Aligned with Arizona's New Economic Initiative
- Support and enable the University of Arizona's growth goals / initiatives
    a. Increase student enrollments
    b. Increase research opportunities and collaborations

III. **Brief Program Description:**

The doctoral (PhD) program in Computer Science and Engineering will provide a unique opportunity for students to deepen their knowledge of computer science and engineering topics by combining theory-based concepts with advanced, enabling computational techniques and technologies to create solutions that address the grand challenges of the 21st century, and beyond.

The PhD Computer Science and Engineering curriculum applies computer science theory and software development fundamentals to produce computing-based solutions. It includes substantial coverage of engineering principles applied to the design of large, networked, scalable computing systems. Competencies include algorithms and complexity, concepts of multiple programming languages, software development, real-time, embedded, and IoT systems design and other broad-based engineering principles.

The curriculum offers highly advanced, specialized, and integrative curriculum in these topics paired with an advanced research component that culminates in a high-impact, archival doctoral dissertation, and publications in peer-reviewed journals with substantial contribution to the research community. The program has a firm engineering foundation that encompasses discovery-based education utilizing an experiential learning approach. As a part of the curriculum, students will complete projects in areas that emphasize computing theory, communication, teamwork, critical thinking, and engineering professionalism. A requirement of the PhD program is engagement in advanced and novel research in areas of computer science and engineering that culminates in scholarly products including a dissertation and other published works. The PhD program's flexibility allows students to design their course of study / research from a diverse pool of courses and research opportunities in software, computer science and computer engineering domains such as web and mobile applications, embedded systems, cybersecurity, machine learning, Quantum computing, systems, and other interdisciplinary areas.

Program Rationale:

Two of the College of Engineering's strategic pillars are:

1) Driving student success for a rapidly changing world, and
2) Tackling critical problems at the edges of human endeavor

The new Computer Science and Engineering PhD degree program plays a critical role in both pillars. The students graduating with a PhD in Computer Science and Engineering degree will be better positioned to develop the skills and mindsets to be leaders in the areas of computing machine learning, ever-increasing automation and connectivity, human and intelligent systems, data science, quantum information engineering, and network sciences.

By offering competitive, relevant, and experiential-based learning to prospective students, the proposed program has the potential to build a strong pipeline for undergraduate and graduate education in Computer Science and Engineering. It will contribute to the much-needed workforce development to close the talent gap in computing and expand the ability to grow research programs that are attractive to forthcoming undergraduate and graduate students. To support the proposed program, we will recruit faculty who can significantly impact computing areas of research and education. These faculty will pursue externally funded, competitive research to advance the state-of-the-art in applied computer science in engineering and integrate their research into the curricula. The broader impacts of these faculty will ultimately lead to a nationally recognized computer science and engineering program at the University of Arizona. It is also anticipated to catalyze collaboration and strengthen the existing electrical and computer engineering program and other engineering disciplines in the College.

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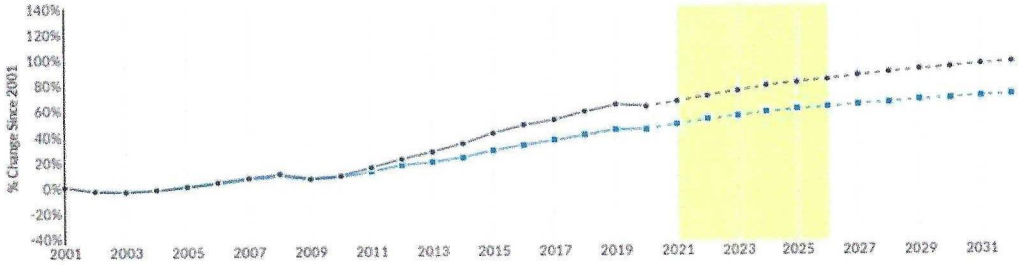
IV. **Projected Enrollment for the First Five Years:** The planned start date for the BS in Computer Science and Engineering is Fall 2023. However, for the PhD program in CSE, the start date is planned to be shifted to one year later, **Fall 2024**. The projected enrollment in the PhD Computer Science Engineering degree program is shown in the table below *(note that it was extended over a 4-year projection beginning in 2024 / 2025 and going thru 2027 / 2028)*. The basis for these projections was derived by comparing enrollments at other AAU universities that have a similar dual Computer Science programs in both their College of Engineering (or similar) and another college, and also using current enrollments in similar UArizona College of Engineering programs.

Degree	Year 0 (2023 / 2024)	Year 1 (2024 / 2025)	Year 2 (2025 / 2026)	Year 3 (2026 / 2027)	Year 4 (2027 / 2028)
PhD	0 ***(Fall 2024 start)***	5	15	30	50

V. **Evidence of Market Demand:** The market demand for those trained in engineering computing disciplines is projected to have significant growth in both the near- and long-term futures. Specifically, the chart below shows the growth in computing-related jobs up to 2021, as well as the projected growth through 2033, both regionally (Arizona, California, Nevada, New Mexico, Utah) and nationally.[1]



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%

Note that computing-related job growth within our region is projected to grow at a faster pace than the nation as a whole. Thus, the new PhD degree program will serve both local, state, and national needs related to employment, economic development, and national security. Indeed, this degree program is among the most important in support of the ongoing fourth industrial revolution and in close alignment with Arizona's New Economy Initiative[2].

[1] Emsi Q2 2022 Data Set, www.economicmodeling.com
[2] World Economic Forum. https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

The full marketing and analysis report for the state of Arizona can be found at the following link:
https://arizona.box.com/s/k4d8cj657sqv6bban2yyi4gcf0paqi0e

The full marketing and analysis report for the nation can be found at the following link:
https://arizona.box.com/s/stizctd27mfeltaxsv2ylmgfa8zgsoco

VI. **Similar Programs Offered at Arizona Public Universities:**

University	Program	College
University of Arizona	PhD Computer Science	College of Science
Arizona State University	PhD Computer Science	School of Computing and Augmented Intelligence, IRA A Fulton Schools of Engineering
Northern Arizona University	PhD Information and Computing	School of Informatics, Computing, and Cyber Systems

VII. **Resources**

a. Summarize new resources required to offer the program *time phased over the next 5 academic years (2023 – 2028)*:

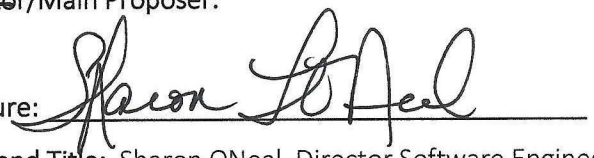
Resources	Quantity
Faculty	4
Staff	0
Other (TAs, Graders, LAs)	0 TAs *(total over next 5 years)* 0 Graders
Equipment	New research and lab equipment is included in the startup packages for new TT faculty
Facilities	Office and lab space *(for new faculty)*

b. Estimate total expected cost: *$2,040,648 (extrapolated over 2023 – 2028)*

c. Estimate total expected revenue of the program: *$869,966 (extrapolated over 2023 – 2028)*

VIII. Required Signatures

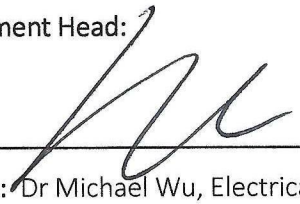
a. ~~Program Director~~/Main Proposer:

i. Signature: 

ii. Name and Title: Sharon ONeal, Director Software Engineering

iii. Date: 10/21/2022

b. Managing Unit/Department Head:

i. Signature: 

ii. Name and Title: Dr Michael Wu, Electrical and Computer Engineering (ECE) Dept Head

iii. Date: 10/21/2022

c. College Dean/Associate Dean:

i. Signature: 

ii. Name and Title: Dr David Hahn, Dean College of Engineering

iii. Date: 10/21/2022

THE UNIVERSITY OF ARIZONA

ACADEMIC PROGRAM – ADDITIONAL INFORMATION FORM

To be used once the preliminary proposal has been approved.

I. MAJOR REQUIREMENTS -

Doctor of Philosophy (PhD) – Computer Science and Engineering

Total units required to complete the degree	63
Pre-admissions expectations (i.e., academic training to be completed prior to admission)	The minimum admission requirements for the Ph.D. program are as follows: • Admission to the Post-M.S. Option requires a master's degree in Engineering, Math, Physics, Computer Science, or Optics. • Admission to the Direct Option requires a bachelor's degree in Engineering, Math, Physics, Computer Science, or Optics. An exceptional record is required for admission into the Ph.D. Direct Option. This option is not available to students who have already completed at least one semester under the UA ECE master's program nor those students who have already completed a master's degree in Engineering, Math, Physics, Computer Science, or Optics. • Minimum GPA of 3.0. • Students who do not have a degree equivalent to the UA Bachelor of Science degree in Electrical & Computer Engineering may be admitted into the graduate ECE program but may be required to complete some courses prior to enrolling in specific graduate courses.
Major requirements. List all major requirements including core and electives. If applicable, list the emphasis requirements for each proposed emphasis*. Courses listed must include course prefix, number, units, and title. Mark new coursework (New). Include any limits/restrictions needed (house number limit, etc.). Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	Students may choose either the ***Direct Option*** or ***Post-MS CSE Option***. The requirements for the ***Post-MS CSE Option*** differ only in that students will begin their PhD program after fulfilling the MS degree requirements in CSE with MS credits counting toward the PhD degree requirements. Specific details will be specified in the CSE Graduate Handbook after the degree program is approved to include language pertaining to earning an MS along the way to the PhD. <u>The requirements outlined below are for the *Direct Option only (36 units):*</u> • Complete 36 units from the 5xx/6xx technical computing courses list that follows or in a closely related computing field (must be approved by Graduate Studies Committee*).*

	• Students are encouraged to select at least one CSE course from each of the three CSE categories (defined below) in their Plan of Study:
	  ○ Systems and Applications
	  ▪ CSE 501 (3) – Operating System Design (NEW)
	  ▪ CSE 504 (3) – Embedded Systems Computing (NEW)
	  ○ Theory of Computation
	  ▪ CSE 503 (3) – Analysis of Algorithms for Engineering Applications (NEW)
	  ▪ CSE 507 (3) – Computer Science and Engineering Research Methods (NEW)
	  ○ Knowledge and Data Engineering
	  ▪ CSE 506 (3) – Database Engineering (NEW)
	  ▪ CSE 505 (3) – Advanced Data Structures (NEW)
	
	• Other stipulations:
	  ○ A maximum of 9 units of non-CSE/ECE coursework. All non-CSE/ECE coursework must be pre-approved by the Graduate Studies Committee prior to registration.
	  ○ A maximum of 3 units of CSE independent study – (CSE 599) (NEW). Non-CSE independent study does not apply toward the coursework requirement. CSE independent study must be taken with a CSE/ECE faculty and must be pre-approved
	
	<u>The requirements outlined below are for the *Post-MS Option only (36 units):*</u>
	
	• 36 total units of graduate coursework (5xx or 6xx) (inclusive of MS coursework) subject to the following limitations:
	  ▪ At least 12 units completed at the UA unique from those completed for a CSE, or equivalent, master's degree.
	  ▪ A maximum of 3 units of CSE 900 Research (NEW) after the master's degree can be counted.
	  ▪ One semester of ECE 695 Colloquium (1 credit) is required for all students entering the CSE PhD degree program.

	Technical Computing Related Courses: • CSE 501 (3) - Operating System Design (NEW) • CSE 502 (3) - Compiler Design (NEW) • CSE 503 (3) - Analysis of Algorithms for Engineering Applications (NEW) • CSE 504 (3) - Embedded Systems Computing (NEW) • CSE 505 (3) – Advanced Data Structures (NEW) • CSE 506(3) – Database Engineering (NEW) • CSE 507(3) – Computer Science and Engineering Research Methods (NEW) • CSE 599 (3) – Independent Study • ECE 503(3) - Probability and Random Processes for Engineering Applications • ECE 506 (3) – Reconfigurable Computing • ECE 509(3) –Cybersecurity Concept, Theory, Practice • ECE 513(3) –Web Development and the IoT • ECE 523(3) –Engineering Applications of Machine Learning and Data Analytics • ECE 540 (3) – Quantum Sensing and Quantum Machine Learning • ECE 562(3) - Computer Architecture and Design • ECE 564(3) – Advanced Topics in Computer Networks • ECE 569(3) – High Performance Computing • ECE 571(3) – Fundamentals of Information and Network Security • ECE 572 (3) – Design, Modeling, and Simulation for High Technology Systems in Medicine • ECE 574A (3) – Computer Aided Logic Design • ECE 576A(3) – Engineering of Computer Based Systems • ECE 576B(3) – Embedded System Design and Optimization • ECE 578(3) – Fundamentals of Computer Networks • ECE 579(3) –Principles of Artificial Intelligence • ECE 677 (3) – Distributed Computing Systems • SFWE 506(3) – Distributed and Parallel Processing • SFWE 507(3) –Data Mining • SIE 533(3) –Fundamentals of Data Science for Engineers • SIE 577(3) – Introduction to Biomedical Informatics

	• *Other courses may be added at the discretion of the faculty advisor with prior approval of the Graduate Studies Committee (GSC)* Complete 9 units of *Minor* Courses (applicable to both Direct and Post-MS Options) at the 6xx level or above (9 units) Complete 18 units of Dissertation Research (applicable to both Direct and Post-MS Options) (18 units): • CSE 920 - Dissertation Research (NEW) (18)
Research methods, data analysis, and methodology requirements (Yes/No). If yes, provide description.	A commitment from an approved CSE Faculty to act as one's research advisor is a requirement of qualification. A Ph.D. aspirant must demonstrate potential for conducting original research. Specific research related requirements are included in the additional requirements section listed in the table below.
Internship, practicum, applied course requirements (Yes/No). If yes, provide description.	None
Master thesis or dissertation required (Yes/No). If yes, provide description.	PhD students are required to complete a dissertation and pass an oral defense of the dissertation which will be administered by an exam committee recommended by the student's Faculty Advisor and approved by the Director of Graduate Studies. The defense will be administered by a committee of at least three tenure-track faculty members, recommended by the student's Faculty Advisor and approved in GRADPATH by the Director of Graduate Studies, including at least three graduate level faculty members with regular or joint appointments in the ECE department, and optionally including one or two graduate level faculty members from another department.
Additional requirements (provide description)	Qualifying Exam Consists of oral questions related to coursework. Must take this exam before the end of the 3rd semester for the post-MS option or the 5th semester for the direct PhD option. The student cannot take the CSE/ECE Written Comprehensive Exam until 12 months after passing the Qualifying Exam. *(A more extensive description of the Qualifying Exam requirements will be contained in the CSE/ECE Graduate Handbook)* CSE Written Comprehensive Exam

	This exam is a written research proposal. Must be submitted to the Comprehensive Exam committee at least **two weeks** before the Oral Comprehensive Exam, which must be taken before the end of the **5th** semester for the post-MS option or the 7th semester for the direct PhD option. Students cannot take the CSE/ECE Written Comprehensive Exam until **12 months** after passing the Qualifying Exam. *(A more extensive description of the CSE Written Comprehensive Exam requirements will be contained in the CSE/ECE Graduate Handbook)* Mid-Degree Paper Direct Ph.D. students are also required to complete a mid-degree paper. Prior to scheduling the Oral Comprehensive Exam, students must submit a paper to a refereed journal or conference. Note: To receive an M.S. degree along the way, complete all M.S. degree requirements and submit a Program Additions and Changes form. *(A more extensive description of the Mid-Degree Paper requirements will be contained in the CSE/ECE Graduate Handbook)* Oral Comprehensive Exam This includes an oral presentation of the research proposal, questioning about the research proposal, and comprehensive technical questioning in the broader field related to the proposed research. Must be taken before the end of the **5th** semester for the post-MS option or the 7th semester for the direct PhD option. Students cannot take the Final Defense until **9 months** after passing the Oral Comprehensive Exam. *(A more extensive description of the Oral Comprehensive Exam requirements will be contained in the CSE/ECE Graduate Handbook)* Papers Must submit a total of **three** technical papers with an ECE faculty member as a co-author: ○ at least two papers to a refereed journal, and ○ one additional paper to a refereed journal or refereed conference *(Note: This three-paper requirement includes the Mid-Degree Paper for direct Ph.D. students.)* Dissertation Defense

	Must pass an oral defense of the dissertation. Students cannot take the Final Defense until **9 months** after passing the Oral Comprehensive Exam. *(A more extensive description of the Dissertation Defense requirements will be contained in the CSE/ECE Graduate Handbook)*
Minor options (as relevant)	Minor – required outside of research as specified above.

*Emphases are officially recognized sub-specializations within the discipline. ABOR Policy 2-221 c. Academic Degree Programs Sub specializations requires all undergraduate emphases within a major to share at least 40% curricular commonality across emphases (known as "major core"). Total units required for each emphasis must be equal. Proposed emphases having similar curriculum with other plans (within department, college, or university) may require completion of an additional comparison chart. Complete the table found in Appendix B to indicate if emphases should be printed on student transcripts and diplomas.

II. **CURRENT COURSES**–using the table below, list all existing courses included in the proposed major. You can find information to complete the table using the UA course catalog or UAnalytics (Catalog and Schedule Dashboard> "Printable Course Descriptions by Department" On Demand Report; right side of screen).

Course prefix and number (include cross-listings)	Units	Title	Pre-requisites	Modes of delivery (online, in-person, hybrid)	Typically Offered (F, W, Sp, Su)	Dept signed party to proposal? (Yes/No)
ECE 503	3	Probability and Random Processes for Engineering Applications	None	In-person	F	Yes
ECE 506	3	Reconfigurable Computing	ECE 562, ECE 574A	In-person, online	Sp	Yes
ECE 509	3	Cybersecurity Concept, Theory, Practice	ECE 578	In-person	Sp	Yes
ECE 513	3	Web Development and the IoT	ECE 275 (or equivalent)	In-person	F	Yes

ECE 523	3	Engineering Applications of Machine Learning and Data Analytics	ECE 503 (or equivalent)	In-person	Sp	Yes
ECE 540	3	Quantum Sensing and Quantum Machine Learning	None	In-person	Sp	Yes
ECE 562	3	Computer Architecture and Design	ECE 369A (or consent of instructor)	In-person	Sp	Yes
ECE 564	3	Advanced Topics in Computer Networks	None	In-person	F	Yes
ECE 569	3	High Performance Computing	Knowledge of computer architecture and digital systems	In-person	F	Yes
ECE 571	3	Fundamentals of Information and Network Security	None	In-person	Sp	Yes
ECE 572	3	Design, Modeling, and Simulation for High Technology Systems in Medicine	None	In-person	F	Yes
ECE 574A	3	Computer Aided Logic and Design	None	In-person	F	Yes
ECE 576A	3	Engineering of Computer Based Systems	ECE 579	In-person	F	Yes
ECE 576B	3	Embedded System Design and Optimization	ECE 576A	In-person	Sp	Yes
ECE 578	3	Fundamentals of Computer Networks	ECE 175 (or equivalent)	In-person, online	F	Yes
ECE 579	3	Principles of Artificial Intelligence	ECE 373 (or equivalent)	In-person	Sp	Yes
ECE 677	3	Distributed Computing Systems	None	In-person, online	F	Yes
SIE 533	3	Fundamentals of Data Science for Engineers	SIE 530 or SIE 500A (or	In-person, online	F	Yes

			consent of instructor)			
SIE 577	3	Introduction to Biomedical Informatics	None	In-person, online	F	Yes

III. 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.

Many of the courses listed below, will be developed as part of the MS in CSE which is part of a separate new program proposal. However, for clarity, they are also included in this proposal since they are new courses to both programs.

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 501	3	Operating System Design	CSE 201 or ECE 275 (or equivalent)	In-person, online	D	Fall 2024	F	Yes	TBR (potentially new faculty)
CSE 502	3	Compiler Design	CSE 201 or ECE 275 (or equivalent)	In-person, online	D	Spring 2025	Sp	Yes	TBR (potentially new faculty)
CSE 503	3	Analysis of Algorithms for Engineering Applications	CSE 201 or ECE 275 (or equivalent)	In-person, online	D	Spring 2025	Sp	Yes	TBR (potentially new faculty)
CSE 504	3	Embedded Systems Computing	CSE 201 or ECE 275 (or equivalent)	In-person, online	D	Fall 2025	F	Yes	TBR (potentially new faculty)
CSE 505	3	Advanced Data Structures	CSE 201 or ECE 275 (or equivalent)	In-person, online	D	Fall 2024	F	Yes	TBR (potentially new faculty)

CSE 506	3	Database Engineering	None	In-person, online	D	Spring 2026	Sp	Yes	TBR (potentially new faculty)
CSE 507	3	Computer Science and Engineering Research Methods	None	In-person, online	D	Fall 2025	F	Yes	TBR (potentially new faculty)
CSE 599	3	Independent Study	None	In-person, online	D	Fall 2024	F,Sp	Yes	Varying
CSE 900	3	Research	None	In-person	D	Fall 2024	F,Sp	Yes	Varying
CSE 920	18	Dissertation	PhD Only	In-person	D	Fall 2025	F,Sp	Yes	Varying

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

The proposed new CSE courses may be sorted into three categories as identified below. Students will be strongly encouraged by graduate advisors to take at least one course from each category in their degree program. Additional new courses will be added as the program grows to increase course selections in each of the category areas. The current proposal is weighted with more existing ECE courses relevant to the CSE graduate degree programs than there are proposed new CSE courses. This is a natural result of the growth process for these degree programs. The CSE graduate program degree proposal specifies robust hiring goals that will necessarily result in the development of a large number of new graduate-level CSE courses that are aligned with new faculty research specializations and areas of emphasis.

	Systems and Applications	Theory of Computation	Knowledge and Data Engineering
Applicable CSE Courses	CSE 501 and CSE 504	CSE 503 and CSE 507	CSE 506 and CSE 505

Click or tap here to enter text.

IV. **FACULTY INFORMATION-** complete the table below. If UA Vitae link is not provided/available, add CVs to a Box folder and provide that link. UA Vitae profiles can be found in the UA directory/phonebook. Add rows as needed. **NOTE: full proposals are distributed campus-wide, posted on committee agendas and should be considered "publicly visible". Contact Office of Curricular Affairs if you have concerns about CV information being "publicly visible".**

Faculty Member	Involvement	UA Vitae link or Box folder link
Dr Tosiron Adegbija	Teach ECE 562 and Conduct/collaborate in CSE related research	Tosiron Adegbija | UA Profiles (arizona.edu)

Dr Abhijit Mahalanobis	Teach ECE 523 and Conduct/collaborate in CSE related research	https://arizona.box.com/s/eximdtrp92tutik04yrfclbyyzj1zidh
Dr Loukas Lazos	Teach ECE 578 and Conduct/collaborate in CSE related research	Loukas Lazos | UA Profiles (arizona.edu)
Dr Salim Hariri	Teach ECE 509 and Conduct/collaborate in CSE related research	Salim A Hariri | UA Profiles (arizona.edu)
Dr Soheil Salehi Mobarakeh	Teach ECE 513 and Conduct/collaborate in CSE related research	Soheil Salehi | UA Profiles (arizona.edu)
Dr Ali Akoglu	Teach ECE 569 and Conduct/collaborate in CSE related research	Ali Akoglu| UA Profiles (arizona.edu)
Dr Michael Marefat	Teach ECE 579 and Conduct/collaborate in CSE related research	Michael M. Marefat | UA Profiles (arizona.edu)
Dr Ravi Tandon	Teach ECE 503 and Conduct/collaborate in CSE related research	https://profiles.arizona.edu/person/tandonr
Dr Tomas Cerny	Teach SFWE 508	Tomas Cerny | UA Profiles (arizona.edu)
Dr Jerzy Rozenblit	Teach ECE 576 A and 576B Conduct/collaborate in CSE related research	https://profiles.arizona.edu/person/jerzyr
Dr Marwan Krunz	Teach ECE 564 and Conduct/collaborate in CSE related research	https://profiles.arizona.edu/person/krunz
Dr Ming Li	Teach ECE 571 and Conduct/collaborate in CSE related research	https://profiles.arizona.edu/person/lim
Dr Michael Wu	Conduct/collaborate in CSE related research	https://arizona.box.com/s/zktwrqsna7r7f53bcubhe4b82m7w9mkd

V. GRADUATION PLAN – provide a ***sample*** degree plan, based on your program that includes all requirements to graduate with this major and takes into consideration course offerings and sequencing.

The table below represents a ***sample*** MS CSE degree plan. Because of the flexibility in the CSE MS degree program, the degree plan of an individual student may differ from what is shown. Each student will develop a tailored degree plan with a member of the CSE graduate advisor and faculty advisor. The student's degree plan will then be approved by the student's faculty advisor and/or the graduate studies

committee.

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
CSE 501 or CSE 504	3	CSE 503 or CSE 507	3	Technical Elective	3	Technical Elective	3
Technical Elective	3	Technical Elective	3	Technical Elective	3	Technical Elective	3
CSE 505 or CSE 506	3	Technical Elective	3	Technical Elective	3	Minor Elective	3
Draft Plan of Study	-			Doctoral Qualifying Exam	-		
Total	9	Total	9	Total	9	Total	9

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
Minor Elective	3	ECE 695	1	CSE 920 - Dissertation (spread over several semesters)	-	CSE 920 - Dissertation (spread over several semesters)	18
Minor Elective	3	Technical Elective	2				
Oral and Written Comprehensive Exam	-						
Total	6	Total	3	Total	-	Total	18

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VI. **Curriculum Map and Assessment Map** - Complete this table as a summary of your learning outcomes and assessment plan, using these examples as a model. If you need assistance completing this table and/or the Curriculum Map, please contact the Office of Instruction and Assessment. Attach your Curriculum Map here.

Program: PhD Computer Science and Engineering

Learning Outcome #1: *Demonstrate broad knowledge in student's field in Computer Science and Engineering.*
Concepts: Study diverse topics in computer science and engineering in the topic areas such as of Systems and Applications, Theory of Computation, and Knowledge and Data Engineering, and others. Students have the option to select from a broad range of software, electrical engineering and computing related technical electives. Courses may include computing topics such as operating system design, compiler design, analysis of algorithms for engineering applications, advanced data structures, database/data engineering, cloud computing, robotics and a variety of other computing topics that vary based on the electives the student opts to take.
Competencies: Demonstrate the ability to research, design, develop, test, integrate and evaluate varied software applications/products/systems in diverse computing and engineering domains. Students opting for the *Thesis-Option* to satisfy their course requirements may also apply their acquired knowledge in these areas to conduct original and novel research in state-of the-art and advanced computer science and engineering principles, processes, and methodologies to meet the requirements/needs of diverse engineering applications.
Assessment Methods: For every new 5xx / 6xx CSE course, a rubric will be created that identifies criteria/source of evidence, assessment measures, and an achievement level rating for specified course performance indicators used to measure this outcome. For each course that contributes to this outcome, specific student artifacts for a given course will be evaluated and assessed. The sources of evidence can include class assignments, exams, projects, papers / reports and other forms of student work. For new courses, the specific evidence used will be defined as the course is developed and re-evaluated as part of the continuous improvement activities for the program/course. For existing courses (predominately technical electives), the evidence used to measure the effectiveness of the student outcome have been defined and will be followed. The rubric achievement levels will include: "Exemplary", "Satisfactory", "Developing", and "Unsatisfactory". At the end of every semester, a team comprised of the course instructor and the ECE Graduate Studies Committee (GSC), will score the rubric using the assessment measures identified for the course. A root cause and corrective action plan will be developed for any course that scores "Developing" or below. Assessment results are documented and formally maintained in a controlled location at the end of each semester and will be published as appropriate. The scores will be tracked over time to facilitate the continuous improvement and corrective action plans remain effective from semester to semester, year to year.
Measures: Rubrics will be used for the specific graded student artifact for a given course that clearly evaluates the learning objectives and outcomes of the assignment and/or projects that students are asked to complete. All rubrics are developed by faculty members with

expertise in computing domains. Faculty may consult with instructional designers as appropriate to ensure the course learning outcomes are measurable and contribute to the overall program learning outcomes. Exams are also used to assess and measure student learning. Throughout the degree program, the student's core course cumulative GPA will be used as a global measure of the overall student CSE knowledge. Additionally, the student's score on the Doctoral Qualifying Exam (DQE) is used to assess the student's fundamental knowledge in specific CSE domains and whether students have a comprehensive understanding of the concepts and theories taught in those domains. The student's score on the Doctoral Comprehensive Exam will also be used to measure the student's background and expertise in the field of their research / dissertation. An exit survey will also be used to measure this outcome after doctoral students have completed their studies/research.

Learning Outcome #2: Critically analyze and review published research results and other literature related to the student's area of study.

Concepts: Synthesize various research techniques to interpret methods used and results from computing related research papers, journals, presentations, and/or conferences. Throughout the program, students will have the opportunity to attend several seminars presented by a diverse group of researchers / scholars and faculty from a broad spectrum of software and computing related fields/areas. They will learn techniques used to critically read published research papers/journals, explore writing techniques used in technical/academic works, learn to develop evidence-based arguments, and draw conclusions from the sources being reviewed. They will also be provided with numerous resources and learn to develop strategies for acquiring and using technical references from a variety of sources.

Competencies: Demonstrate the ability to read and interpret various forms of computing research information, papers, conference proceedings, and data collected to support research. Students will also demonstrate their understanding of techniques used to write technical papers and journal articles. Students will also be able to analyze and explain research approaches taken and results included in published computing research papers, journals and conference proceedings.

Assessment Methods: This outcome will be assessed in CSE related research papers written and submitted to various technical publications and journals or conferences. If the student elects the MS Thesis option as part of their plan of study, the thesis project under the guidance of a faculty advisor, is reviewed by an examining committee prior to an oral presentation. This learning outcome is also be assessed via the written Doctoral Comprehensive Exam which includes a dissertation proposal related to the students CSE area of specialization. The written exam is followed by an Oral Comprehensive Exam which is held with a review committee and typically contains a presentation based on the proposed dissertation research.

Measures: Instructor grading of research related coursework in CSE 507, results from a student's thesis defense using the collective results of a Program Assessment Survey completed by various thesis committee members, and the results of the student's final oral defense of their dissertation.

Learning Outcome #3: *Conduct in-depth original research in a computer science and engineering application area/field.*

Concepts: Utilize acquired knowledge and new research strategies to conduct novel research in a computer science and engineering field of specialization. Students will meet regularly with their faculty advisor and others within the ECE department to receive guidance and coaching in a variety of research areas. Students will summarize all aspects of their research and their findings in a written dissertation that will be defended orally before a faculty committee appointed by the Dean of the Graduate College.

Competencies: Demonstrate the ability to articulate all aspects of their research in a CSE specialization area, describe and defend the significance of their research, describe methodologies used in conducting the research, and summarize their overall findings resulting from said research.
Assessment Methods: A dissertation committee will assess the originality, merit, and contributions of the candidate's research. The written dissertation and oral defense is facilitated by a faculty committee appointed by the Dean of the Graduate College in consultation with the major department and chaired by the faculty advisor. The presentation portion of the oral defense is open to the public. Following the public presentation and discussion, the candidate will participate in a closed meeting with the committee for further evaluation.
Measures: Evaluation of the student's final written dissertation. The dissertation will be evaluated by a faculty led committee that assesses the originality, merit, and contributions of the candidate's research. This includes their ability to (a) identify and critically evaluate relevant literature, (b) formulate and solve original problems using computational theory and methods, and (c) interpret and communicate research ideas, data and findings.
Learning Outcome #4: *Communicate and defend (written and oral) results of projects or research to peers and broader engineering audiences.*
Concepts: Utilize their acquired CSE skills and knowledge to communicate effectively in both written and oral mediums. This may be accomplished in a variety of methods including submitting research papers to technical journals, submitting / presenting at technical conferences, and/or presenting their research to others via seminars and colloquium presentations. Additionally, doctoral candidates will prepare a written dissertation that demonstrates all aspects of their research including the significance of their work, a detailed review of relevant literature, methodologies employed and/or developed, significant findings from the work, a critical discussion of the findings, limitations, and the impact, and potential for future research. When the doctoral candidate has met the rigor and standards of scholarship and has documented the research in a dissertation, the candidate will publicly defend the dissertation and answer any questions related to their work.
Competencies: Demonstrate their ability to articulate all aspects of the research in a computer science and engineering specialization area, describe and defend the significance of their research, describe methodologies used in conducting the research, and summarize their overall findings resulting from said research.
Assessment Methods: A dissertation committee will assess the originality, merit, and contributions of the candidate's research. The written dissertation and oral defense is facilitated by a faculty committee appointed by the Dean of the Graduate College in consultation with the ECE department and chaired by the faculty advisor. The presentation portion of the oral defense is open to the public. Following the public presentation and discussion, the candidate will participate in a closed meeting with the committee for further evaluation.
Measures: Evaluation of the student's final written and oral dissertation. The dissertation will be evaluated by a faculty led committee that assesses the originality, merit, and contributions of the candidate's research. This includes their ability to (a) identify and critically evaluate relevant literature, (b) formulate and solve original problems using computational and engineering theory and methods, and (c) interpret and communicate research ideas and findings.

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The Taskstream Curriculum Map is shown below. Note that the assessment plan includes only new CSE courses that are part of this program. Existing ECE courses used to fulfill the degree requirements are not included. The assessment plans for existing courses will be followed per the department's assessment plan for each respective existing course.

PhD Computer Science and Engineering

Courses and Activities Mapped to PhD Computer Science and Engineering

	Outcome			
	SLO 1 Demonstrate broad knowledge in the student's field in Computer Science and Engineering.	SLO 2 Critically analyze and review published research results and other literature related to the student's area of study.	SLO 3 Conduct in-depth original research in a computing application area / field.	SLO 4 Communicate and defend (written and oral) results of projects or research to peers and broader engineering audiences.
Courses and Learning Activities				
CSE 501 Operating System Design (Core Elective)	P/A			
CSE 503 Analysis of Algorithms for Engineering Applications (Core Elective)	P/A			P/A
CSE 504 Embedded Systems Computing (Core Elective)	P/A			
CSE 505 Advanced Data Structures (Core Elective)	P/A			
CSE 506 Database Engineering (Core Elective)	P/A			
CSE 507 Computer Science and Engineering Research Methods (Core Elective)	P/A	IPA	I	IPA
ECE 695 Colloquium (Required)		P/A		
CSE 920 Dissertation Research (Required)	P/A	P/A	P/A	P/A
CSE 502 Compiler Design (Computing Elective)	P/A			
CSE 900 Research (Computing Elective)	P/A	P/A	P/A	P/A
Exit Survey Exit survey (Indirect)	A	A	A	A

Legend: I Introduced | P Practiced | A Assessed | I/P Introduced/Pract

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VII. **PROGRAM ASSESSMENT PLAN-** using the table below, provide a schedule for program evaluation 1) while students are in the program and 2) after completion of the major. Add rows as needed. Delete EXAMPLE rows.

Assessment Measure	Source(s) of Evidence	Data Collection Point(s)
Rubrics for all new courses used to assess each student outcome that identifies criteria, measure of assessment, and an achievement level rating *(i.e., Exemplary, Satisfactory, Developing, Unsatisfactory).*	Specifically targeted: • Class assignments • Exams • Course Projects • Course Reports • Other forms of student work tailored to any specific course)	End of each semester the specific courses are taught.
Doctoral Qualifying Exam (DQE)	• Students grades in CSE graduate level courses taken during the first year of their studies. • Score on the DQE	This exam is administered at the start of every academic year. Students are required to take the exam at the start of their second year in the program.
Doctoral Comprehensive Exam	• Written Comprehensive Exam score • Oral Comprehensive Exam score	The comprehensive exam is typically taken at least a semester to a year before the final dissertation defense. It is recommended that the comprehensive exam is taken at least nine months before the final defense.
Doctoral Final Written Dissertation	Written Dissertation	Published and evaluated at the conclusion of the candidate's doctoral research efforts to assess the merit and contributions of the candidate's doctoral research.
Doctoral Oral Dissertation Defense	Oral Defense of the student's Dissertation	When the doctoral candidate has met the rigor and standards of scholarship and has documented the research in a dissertation, the candidate will publicly defend the dissertation and answer any general questions related to their work.
Graduation exit survey (used for indirect measures of outcomes).	Student survey	At student graduation

VIII. **ANTICIPATED STUDENT ENROLLMENT**-complete the table below. What concrete evidence/data was used to arrive at the numbers?

5-YEAR PROJECTED ANNUAL ENROLLMENT					
	1st Year	2nd Year	3rd Year	4th Year	5th Year
Number of Students					
PhD Degree	5	15	30	50	60

Data/evidence used to determine projected enrollment numbers:

Note: the enrollment numbers shown in the table above reflect the enrollments that begin in academic year 2024/2025 (Year 1).

Several regional and/or AAU universities with MS and PhD Computer Science programs inside Engineering were canvassed for program enrollment in 2020. The table that follows shows the total enrollment in some of these programs[1]:

University	PhD Computer Science and Engineering Student Enrollment
University of California - Berkeley	2
University of California - Davis	134
University of Michigan	233
University of Florida	88
University of Illinois – Urbana – Champaign	422
Arizona State University	206
The Ohio State University	168
University of Minnesota – Twin Cities	199

[1] Enrollments derived from https://shinyapps.asee.org/apps/Profiles/

IX. **ANTICIPATED DEGREES AWARDED**- complete the table below, beginning with the first year in which degrees will be awarded. How did you arrive at these numbers? Take into consideration departmental retention rates. Use National Center for Education Statistics College Navigator to find program completion information of peer institutions offering the same or a similar program.

PROJECTED DEGREES AWARDED ANNUALLY					
	1st Year	2nd Year	3rd Year	4th Year	5th Year
Number of Degrees	0	0	6	10	20

Data/evidence used to determine number of anticipated degrees awarded annually:

The estimates in the table above are based on the projected total enrollments over the first 5 years of the program, which includes potential student transfers into the program in the earlier years of the program. Students are expected to graduate as soon as the second year of the program.

Additionally, an analysis of other university graduation rates in similar programs was performed as defined in the National Center for Education Statistics[2]. Interestingly, this source did not specifically call out computer science and engineering programs, and therefore we also researched degrees awarded at ASEE[3]. The universities considered are shown in the table below:

University	Number of PhD Awards Conferred in 2020 (NCES)	Number of PhD Awards Conferred in 2020 (ASEE)
University of California - Berkeley	Not specifically listed	40
University of California - Davis	Not specifically listed	21
University of Michigan	Not specifically listed	33
University of Florida	Not specifically listed	8
University of Illinois – Urbana – Champaign	Not specifically listed	48
Arizona State University	Not specifically listed	33

[2] https://nces.ed.gov/collegenavigator/

[3] https://shinyapps.asee.org/apps/Profiles/

The Ohio State University	Not specifically listed	31
University of Minnesota – Twin Cities	Not specifically listed	22

X. **PROGRAM DEVELOPMENT TIMELINE-** describe plans and timelines for 1) marketing the major and 2) student recruitment activities.

The graduate level programs in Computer Science and Engineering utilize several existing courses within the College of Engineering, including:

- Electrical and Computer Engineering (ECE) Department
- Software Engineering (SFWE) program (which is co-owned by ECE and SIE)
- Systems and Industrial Engineering (SIE) Dept

The table below shows the preliminary plan for the ***new*** MS Computer Science and Engineering course development required for the program. We will work closely with UArizona's University Center for Assessment, Teaching and Technology (UCATT) and UA Online to execute the plan shown in the table below.

Course Number / Name	Planned Development Timeframe	First Semester Offered
CSE 501 - Operating System Design	Spring 2023	Fall 2024
CSE 502 - Compiler Design	Fall 2024	Spring 2025
CSE 503 - Analysis of Algorithms for Engineering Applications	Fall 2024	Spring 2025
CSE 504 - Embedded Systems Computing	Spring 2025	Fall 2025
CSE 505 - Advanced Data Structures	Spring 2024	Fall 2024
CSE 506 - Database Engineering	Fall 2025	Spring 2026
CSE 507 - Computer Science and Engineering Research Methods	Spring 2025	Fall 2025
CSE 599 – Independent Study	Spring 2024	Fall 2024
CSE 900 – Research (PhD only)	Spring 2024	Fall 2024
CSE 920 – Dissertation (PhD only)	Spring 2025	Fall 2025

We will also work closely with the recruitment and marketing teams (MarCom) within the College of Engineering to market the program as soon as ABOR approves the degree program. Additionally, we will work closely with Arizona Online and Distance learning to market the program through their marketing channels.

IX. **Program Fees and Differential Tuition (PFDT) Request** – For implementation of fees, you must work with University Fees. The annual deadline is December 1. For any questions, please contact the University Fees Program Manager.

None planned for this program.

Appendix A. Minor or Master's Requirements. Complete if requesting a corresponding minor/master's. Delete EXAMPLE column and verbiage as it applies to your level degree (i.e., undergraduate vs graduate) before submitting.

Not Applicable

Appendix B. Emphasis Print Information-if applicable, complete the table below to indicate if proposed emphases should be printed on transcript and diploma. Add rows as needed. Note: emphases are displayed on transcript and diplomas as " _____ Emphasis".

Emphasis	Print on transcript	Print on diploma
Not Applicable	N/A	N/A

Graduate Major Peer Comparison Chart-select two peers for completing the comparison chart from (in order of priority) ABOR-approved institutions, AAU members, and/or other relevant institutions recognized in the field. The comparison chart will be used to identify typically required coursework, themes, and experiences for majors within the discipline. The comparison programs are not required to have the same degree type and/or major name as the proposed UA program. Information for the proposed UA program must be consistent throughout the proposal documents. Delete EXAMPLE columns once ready to submit/upload.

Program name, emphasis (sub-plan) name (if applicable), degree, and institution	**Proposed UA Program:**	**Peer 1:** PhD in Computer Science – University of Florida / Computer and Information Science and Engineering (CISE)	**Peer 2:** PhD in Computer Science and Engineering – University of Michigan
Current # of enrolled students		88	233
Major Description. Includes the purpose, nature, and highlights of the curriculum, faculty expertise, emphases (sub-plans; if any), etc.	The PhD Computer Science and Engineering curriculum applies computer science theory and software development fundamentals to produce computing-based solutions. It includes substantial coverage of algorithms and complexity, computer science theory, concepts of multiple programming languages, software development, and engineering principles. The PhD curriculum builds upon the MS CSE program by adding additional coursework and research opportunities for students wishing to pursue a PhD in Computer Science and Engineering. Both programs have a firm engineering foundation that encompasses discovery-based education utilizing an experiential learning approach. As a part of both curriculums, students will complete projects in areas that emphasize computing theory, communication, teamwork, critical thinking, and engineering professionalism. As part of the PhD program, students will also conduct novel research in many	The Computer Science program combines a strong engineering oriented technical basis with a flexible interdisciplinary component and an emphasis on communication skills. This flexibility will be increasingly important in the future as computers become important tools in an ever-increasing number of fields. Students in the engineering computer science (EG-CSE) program will satisfy the same requirements for general education and obtain the same engineering pre-professional background in mathematics and science as other engineering students. The program contains a strong technical component comprising a set of required courses covering essential areas in computing and a set of technical electives enabling students to deepen their knowledge in chosen areas of computer science and engineering.	The doctoral degree, i.e. the Ph.D., is primarily intended for students desiring a career in research and/or collegiate teaching. The focus is on advanced CSE topics, on learning to perform research and to write research papers, and on making fundamental new contributions to a CSE topic. Students take advanced course work and write a *doctoral dissertation*, also called a *thesis*. Students newly admitted to the doctoral program are classified as *precandidates*. Upon entering a doctoral program, there is a Ph.D. qualifying process, normally completed during the first two years. After all requirements except the dissertation are completed, students become *candidates*. Students entering a CSE doctoral program with a bachelor's degree typically become candidates in the third year and and are strongly encouraged to complete the degree within five years. Such students ordinarily complete the requirements for a master's degree along the way and receive this degree in

	diverse computer science related areas. The PhD program's flexibility allows students to design their course of study / research from a diverse pool of courses and research opportunities in software, computer science and computer engineering domains such as web and mobile applications, embedded systems, cybersecurity, machine learning, systems, and other interdisciplinary areas.	In addition, the program includes a set of interdisciplinary electives in an area of the student's choice. This area may be chosen from anything the university has to offer. Students may choose an established minor, a predefined "track," or if nothing available meets their needs, work with an advisor to develop their own program. To answer the demands of industry for employees with both technical competence and the ability to communicate effectively, the program requires communication courses beyond the usual engineering general education requirements.	addition to the Ph.D. A masters thesis is optional. Students who enter a CSE doctoral program with a master's in the field of their program typically become candidates in their second year and are strongly encouraged to complete the degree within four years. Such students are not ordinarily eligible to receive a CSE master's degree.

Target careers	• Software developer
	• Software researcher
	• University professor
	• Computer Science engineer / researcher for variety of application areas:
	  ○ Web
	  ○ Mobile
	  ○ Embedded systems
	  ○ Avionics
	  ○ Robotics
	  ○ Machine Learning
	  ○ Data Management / Data Science
	  ○ Mobile Application developer
	  ○ Other software related fields
		• Software developer
		• Software researcher
		• University professor
		• Computer Science engineer / researcher for variety of application areas:
		  ○ Web
		  ○ Mobile
		  ○ Embedded systems
		  ○ Avionics
		  ○ Robotics
		  ○ Machine Learning
		  ○ Data Management / Data Science
		  ○ Mobile Application developer
		  ○ Other software related fields
			• Software developer
			• Software researcher
			• University professor
			• Computer Science engineer / researcher for variety of application areas:
			  ○ Web
			  ○ Mobile
			  ○ Embedded systems
			  ○ Avionics
			  ○ Robotics
			  ○ Machine Learning
			  ○ Data Management / Data Science
			  ○ Mobile Application developer
			  ○ Other software related fields

Total units required to complete the degree	63	90	50+
Pre-admission expectations (i.e. academic training to be completed prior to admission)	• Bachelor's degree from an accredited institution recognized by the UA. Students who do not have a degree equivalent to a UA Bachelor of Science degree in a computing related program may be admitted into the graduate CSE program but may be required	To earn a Ph.D. degree, a student must satisfy a minimum of 90 graduate-level credits beyond the bachelor's degree. Up to 30 credits from a prior master's degree in Computer Science or Computer Engineering taken either at the University of Florida	We expect applicants to have earned their bachelor's degrees by the time they matriculate, and to possess strong backgrounds in computer science or a related discipline.

	to complete some undergraduate deficiency courses prior to enrolling in graduate courses. This policy also applies to students in the MS non-thesis option. • Minimum GPA of 3.0. • Applicants whose native language is not English are required by the Graduate College to take an English Proficiency tests (see Graduate College admissions requirements website). • Students in the MS non-thesis option are expected to be self-supported or supported by external fellowships or industry.	or from another accredited institution may be transferred and counted towards the Ph.D. degree. Students must apply for the credit transfer during their first term of enrollment. Approval by the graduate school is necessary for the credit transfer. Beyond the first 30 credits counted toward the Ph.D. degree, students must complete at least 30 credits at the University of Florida campus.	• If your degree is from a non-US institution, verify if your degree meets our bachelor's degree requirement here • If you have a MS or PhD in computer science or an equivalent field from another institution, you cannot apply for the same degree at the University of Michigan Successful applicants usually have an undergraduate GPA of at least 3.5/4.0 and three strong letters of recommendation. International students must demonstrate English proficiency. Further information may be found here. Students admitted to the PhD program generally exceed these standards. In addition, students admitted to the Ph.D. program often have prior research experience or have demonstrated research aptitude. *Beginning the 2022-2023 admissions cycle, GRE scores are not included in the admissions review of Ph.D. applications (more information available). GRE scores are neither required nor considered for MS applicants.*
Major requirements. List all major requirements including core and electives. If applicable, list the emphasis requirements. Courses listed must include course prefix, number, units, and title. Mark	Students may choose either the ***Direct Option*** or ***Post-MS CSE Option***. The requirements for the ***Post-MS CSE Option*** differ only in that students will begin their PhD program after fulfilling the MS degree requirements in CSE with MS credits counting toward the PhD degree requirements. Specific details will be specified in the CSE Graduate Handbook after the degree program is approved.	**Core Courses:** **Computer Systems:** *Select 2 from the following (6 units):* • CDA 5155 Computer Architecture Principles (3) • COP 5615 Distributed Operating System Principles (3) • COP 5556 Programming Language Principles (3) • CNT 5106C Computer Networks (3)	PhD Requirements Students should note the general requirements for graduate studies stated on rackham.umich.edu as well as the requirements stated in this brochure. **It is the student's responsibility to ensure that all requirements are satisfactorily met.** A student earns a CSE Ph.D. in three stages:

new coursework (New). Include any limits/restrictions needed (house number limit, etc.). Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	**<u>The requirements outlined below are for the *Direct Option only (36 units):*</u>** • Complete 36 units from the 5xx/6xx technical computing courses list that follows or in a closely related computing field (must be approved by Graduate Studies Committee*).* • Suggested that students select at least one CSE course from each of the three CSE categories (defined below) in their Plan of Study: ○ Systems and Applications ▪ CSE 501 (3) – Operating System Design (NEW) ▪ CSE 504 (3) – Embedded Systems Computing (NEW) ○ Theory of Computation ▪ CSE 503 (3) – Analysis of Algorithms for Engineering Applications (NEW) ▪ CSE 507 (3) – Computer Science and Engineering Research Methods (NEW) ○ Knowledge and Data Engineering ▪ CSE 506 (3) – Database Engineering (NEW) ▪ CSE 505 (3) – Advanced Data Structures (NEW) • Other stipulations: ○ A maximum of 9 units of non-CSE/ECE coursework. All non-CSE/ECE coursework must be pre-approved by the Graduate Studies Committee prior to registration. ○ A maximum of 3 units of CSE independent study – (CSE 599) (NEW). Non-CSE independent study does not apply toward the coursework requirement. CSE independent study must be taken with a	**Theory:** *Select 2 from the following (6 units):* • COT 5405 Analysis of Algorithms • COT 5536 Advanced Data Structures • COT 6315 Formal Languages and Computation Theory **For students without a prior MS degree in Computer Science or Computer Engineering:** • 24 credits of CISE graduate-level courses • Minimum of 3 credits of CIS 7980 Research for Doctoral Dissertation • Other graduate level courses including any research credits are at the discretion of the student and the supervisory committee chair • Up to 6 credits of EGN 5949 (Internship) allowed **For students with a prior MS degree in Computer Science or Computer Engineering:** • 6 credits of CISE graduate-level courses • Minimum of 3 credits of CIS 7980 Research for Doctoral Dissertation • Other graduate level courses including any research credits are at the discretion of the student and the supervisory committee chair • Up to 6 credits of EGN 5949 (Internship) allowed A list of CISE graduate level courses and their descriptions can be found at: CISE Graduate Courses • Full time, on-campus PhD students must complete 3 credits of Graduate Seminar. • Students must take and pass a Written Qualifying Exam covering the literature of an area in computing.	1. Qualification for the CSE Ph.D. requires the following: • Breadth Coursework • Depth Coursework • Directed study Coursework/Research • Preliminary Examination • Reciprocal working relationship with an EECS Faculty member (research advisor) 2. Candidacy for the Ph.D. requires the following: • Successful qualification in the CSE Program; • Completion of all Rackham requirements for Candidacy, including the 3-hour cognate requirement. (Beginning Fall 2014, Rackham requires that all Responsible Conduct of Research and Scholarship (RCRS) requirements must be met before candidacy). 3. Dissertation and defense: • Identify a research advisor and agree on a topic; • Identify a doctoral committee; • Submit and defend a proposal for the content of the doctoral research; • Do the research and write the dissertation; • Submit and defend the dissertation. For a list of courses available to satisfy the breadth requirement in each area, please consult CSE's course and degree satisfaction list for terminal master's students.

	CSE/ECE faculty and must be pre-approved **<u>The requirements outlined below are for the *Post-MS Option only (36 units):*</u>** • 36 total units of graduate coursework (5xx or 6xx) (inclusive of MS coursework) subject to the following limitations: ▪ At least 12 unique units completed at the UA after a CSE, or equivalent, master's degree. ▪ A maximum of **3** units of CSE 900 Research (NEW) after the master's degree can be counted. ▪ One semester of ECE 695 Colloquium (1 credit) is required for all students entering the CSE PhD degree program. **<u>Technical Computing Related Courses:</u>** • CSE 501 (3) - Operating System Design (NEW) • CSE 502 (3) - Compiler Design (NEW) • CSE 503 (3) - Analysis of Algorithms for Engineering Applications (NEW) • CSE 504 (3) - Embedded Systems Computing (NEW) • CSE 505 (3) – Advanced Data Structures (NEW) • CSE 506(3) – Database Engineering (NEW) • CSE 507(3) – Computer Science and Engineering Research Methods (NEW) • CSE 599 (3) – Independent Study • ECE 503(3) - Probability and Random Processes for Engineering Applications • ECE 506 (3) – Reconfigurable Computing • ECE 509(3) –Cybersecurity Concept, Theory, Practice	• Students may apply for advancement to PhD candidacy by scheduling an oral exam after passing the Written Qualifying Exam. • A PhD student is allowed to earn a MS-on-the-way or MS-en-route to-PhD prior to admission of candidacy. • All PhD students are required to complete and defend a dissertation of publishable quality.	

	• ECE 513(3) –Web Development and the IoT • ECE 523(3) –Engineering Applications of Machine Learning and Data Analytics • ECE 540 (3) – Quantum Sensing and Quantum Machine Learning • ECE 562(3) - Computer Architecture and Design • ECE 564(3) – Advanced Topics in Computer Networks • ECE 569(3) – High Performance Computing • ECE 571(3) – Fundamentals of Information and Network Security • ECE 572 (3) – Design, Modeling, and Simulation for High Technology Systems in Medicine • ECE 574A (3) – Computer Aided Logic Design • ECE 576A(3) – Engineering of Computer Based Systems • ECE 576B(3) – Embedded System Design and Optimization • ECE 578(3) – Fundamentals of Computer Networks • ECE 579(3) –Principles of Artificial Intelligence • ECE 677 (3) – Distributed Computing Systems • SFWE 506(3) – Distributed and Parallel Processing • SFWE 507(3) –Data Mining • SFWE 508(3) – Cloud Computing Principles and Practices • SIE 533(3) –Fundamentals of Data Science for Engineers • SIE 577(3) – Introduction to Biomedical Informatics • *Other courses may be added at the discretion of the faculty advisor with prior approval of the Graduate Studies Committee (GSC)* **Complete 9 units of *Minor* Courses (applicable to both Direct and Post-MS Options) at the 6xx level or above (9 units)**		

	Complete 18 units of Dissertation Research (applicable to both Direct and Post-MS Options) (18 units): • CSE 920 - Dissertation Research (NEW) (18)		
Research methods, data analysis, and methodology requirements (Yes/No). If yes, provide description.	PhD students are required to complete a dissertation and defend their dissertation	A minimum of 3 credit hours of CIS 7890 Research for Doctoral Dissertation + Dissertation	Submit thesis proposal and after successfully presenting that, proceed with thesis research and dissertation / defense
Internship, practicum, applied course requirements (Yes/No). If yes, provide description.	Not required	Not required	Not required
Master thesis or dissertation required (Yes/No). If yes, provide description.		All PhD students are required to complete and defend a dissertation of publishable quality.	Submit thesis proposal and after successfully presenting that, proceed with thesis research and dissertation / defense
Additional requirements (provide description)	A cumulative GPA of 3.0 / 4.0 or higher must be maintained on all coursework taken for graduate credit. A grade of C or higher is required for a course to be used to satisfy the degree requirements (A or B for transfer credits). Grade Replacement Option cannot be used for graduate courses.	• Must maintain at least a 3.0 GPA in 3 of the required 4 core courses • Full time, on-campus PhD students must complete 3 credits of Graduate Seminar. • Students must take and pass a Written Qualifying Exam covering the literature of an area in computing. • Students may apply for advancement to PhD candidacy by scheduling an oral exam after passing the Written Qualifying Exam. • A PhD student is allowed to earn a MS-on-the-way or MS-en-route to-PhD prior to admission of candidacy. • All PhD students are required to complete and defend a dissertation of publishable quality.	A Ph.D. student must have a 3.5 GPA overall and a 3.5 GPA for all CSE courses to sign up for the qualification exams. See the Rackham Graduate School Academic Policies: rackham.umich.edu.)

*Note: comparison of additional relevant programs may be requested.

From:	Valerdi, Ricardo - (rvalerdi)
To:	ONeal, Sharon L - (sharononeal)
Cc:	Wu, Michael H. - (mhwu); Hahn, David W - (dwhahn)
Subject:	Re: Letter of Support - Computer Science and Engineering Degree Programs
Date:	Saturday, October 8, 2022 6:25:23 PM
Attachments:	image001.png image002.png

Sharon,
The SIE Department supports the proposed degree programs and commits to ongoing offerings of the courses listed below.

Regards,

-Ricardo

From: ONeal, Sharon L - (sharononeal) <sharononeal@arizona.edu>
Sent: Saturday, October 8, 2022 8:08:00 PM
To: Valerdi, Ricardo - (rvalerdi) <rvalerdi@arizona.edu>
Cc: Wu, Michael H. - (mhwu) <mhwu@arizona.edu>; Hahn, David W - (dwhahn) <dwhahn@arizona.edu>
Subject: Letter of Support - Computer Science and Engineering Degree Programs

Ricardo,
The College of Engineering and the Electrical and Computer Engineering Department are proposing a new BS undergraduate degree in Computer Science and Engineering (CSE) beginning in Fall 2023 to be taught in both the In-person and Online modalities. We are also planning to subsequently offer a MS and PhD program to begin in 2024/2025 academic year.

The CSE curriculum applies computer science theory and software development fundamentals to produce computing-based solutions. It includes substantial coverage of algorithms and complexity, computer science theory, concepts of multiple programming languages, software development, and engineering principles. The program has a firm engineering foundation that is ABET CAC / EAC compliant.

We have obtained very enthusiastic endorsements from Provost Folks, Vice-Provost Heileman and Dean Hahn (CoE) for this new degree.

The table below summarizes the full-time projected enrollments in the CSE program extrapolated out over the first 5 years, at which we believe we will achieve a steady enrollment number. These numbers were estimated based on actual enrollments[1] in other AAU universities that have dual computer science programs in the College of Engineering and a Computer Science program in another college.

Computer Science and Engineering Projected Enrollments *(all programs)*					
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
MS	0	10	30	60	120
PhD	0	5	15	30	50

As part of the BS curriculum, the following course(s) from your Dept will be required for the degree:

SIE 305 – Introduction to Probability and Statistics
SFWE 302 – Software Architecture and Design *(co-owned with ECE)*
SFWE 402 – Software DevSecOps *(co-owned with ECE)*

As part of the graduate program, the following classes may be taken as electives by the MS / PhD CSE students:

SIE 533 –Fundamentals of Data Science for Engineers
SIE 578 –Artificial Intelligence for Health and Medicine

I'm writing to obtain your support for our plan to require these courses in our supporting coursework. Kindly respond with your acknowledgement and support for these new degree programs, so that it can be incorporated in the proposal that we are finalizing to submit for ABOR approval in early 2023.

If you have any questions, please feel free to reach out either via email or by cell at (520) 822-4040.

Sharon ONeal

Software Engineering

SOFTWARE ENGINEERING est. 2021

Sharon ONeal
Professor and
Director, Software Engineering

Phone: 520-621-2558
Mobile: 520-822-4040 *(preferred)*
Email: sharononeal@email.arizona.edu

[1] Enrollments derived from https://shinyapps.asee.org/apps/Profiles/

THE UNIVERSITY OF ARIZONA

01/20/2023

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 Garzione

Dean Garzione

Jan. 31, 2023

Date

Dean Hahn

Jan. 22, 2023

Date

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

THE UNIVERSITY OF ARIZONA

College of Science
Office of the Dean

1040 E. Fourth Street
Gould Simpson Bldg. Room 1025
PO Box 210077
Tucson, AZ 85721-0077
T: (520) 621-4090
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cos.arizona.edu

November 28, 2023

To: Dean David Hahn, College of Engineering

From: Carmie Garzione, Dean, College of Science

The College of Science and the Department of Computer Science are supportive of the College of Engineering's proposed M.S. and Ph.D. programs in Computer Science and Engineering. We look forward to working with Engineering to highlight our complementary strengths in computing disciplines and helping students identify the degree pathways that best meet their goals.

COLLEGE OF ENGINEERING
Office of the Dean
1209 E. 2nd Street, Room 100
Tucson, AZ 85721-0072

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engineering.arizona.edu

THE UNIVERSITY OF ARIZONA
College of Engineering

November 24, 2023

To: University of Arizona Faculty Senate

From: David W. Hahn, Craig M. Berge Dean, College of Engineering

Subject: Computer Science and Engineering MS and PhD degrees

This memo is submitted as an addendum to our current proposals for new MS and PhD degrees in Computer Science and Engineering (CSE) and is intended to provide clarity on the financial aspects of both degrees. A related new degree was approved and implemented for the Fall 2023 term, namely the new BS in Computer Science and Engineering. A plan is currently in place to hire 10 additional faculty members at the ranks of assistant professor, associate professor, full professor, and professor of practice over the next 3 years. The exact distribution will be determined through the search processes.

The additional 10 faculty, along with existing faculty in Electrical and Computer Engineering (ECE), the academic home of the new two proposed degrees, and leveraging some faculty from Systems and Industrial Engineering (SIE) from the existing Software Engineering program, are sufficient to teach the existing BS CSE and the new MS and PhD CSE degrees, as outlined in detail in the two proposals before the Faculty Senate.

The College of Engineering has committed $3M to hire the new faculty over a three-year period. This money, with concurrence of senior campus leadership, was redirected from a previous ENGR commitment to support the new Computer Science and Engineering program. As such this represents a new and fully dedicated revenue source to establish the CSE program, including the two new proposed degrees.

By the 5th program year (1st year is 2023-24 AY), a projected total cohort size of 450 undergraduate students and 50 graduate students will generate revenue estimated in excess of $2.5M per current AIB metrics, with a new faculty payroll estimated under $2M (salary and fringe). Additional faculty will be added in consideration of total enrollment and revenue models, all in the context of program financial sustainability. I add that there is considerable financial savings by using the existing infrastructure (leadership, faculty and staff) of the existing ECE department, avoiding unnecessary administrative growth.

I appreciate your consideration and am happy to provide any additional information.