ARIZONA BOARD OF REGENTS
ASU ◆ NAU ◆ UA

Request to Establish New Academic Program in Arizona

Please complete all fields. Boxes may be expanded to accommodate longer responses. Clarifying field descriptions can be found below. Should you have any questions or concerns, please email Helen Baxendale, Director of Academic Affairs and Policy at helen.baxendale@azregents.edu

University:

Name of Proposed Academic Program:

Master of Science Computer Science and Engineering (CSE)

Academic Department:

College of Engineering: 2303 - Electrical and Computer Engineering Department

Geographic Site:

Main Campus (Tucson) and UArizona Online

Instructional Modality:
In person and online via UA ONLN

Total Credit Hours:

30 units

Proposed Inception Term:
The term and year in which the program will be first delivered (i.e., Spring 2021; Fall 2022).

Fall 2024

Brief Program Description:
A short outline of the content and skills that the proposed program will deliver. A brief description of how the program fits into the institutional mission of the university. If relevant, please provide succinct information about existing related or complementary academic programming.

The MS graduate 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 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 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. If the student chooses the thesis option, they will conduct novel research in areas of computer science and engineering that culminates in scholarly products including a thesis and other published works. The 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.

Learning Outcomes and Assessment Plan:
Define the core concepts and competencies that the program will convey and stipulate how these key learning outcomes will be measured and assessed.

Learning Outcome #1 (Thesis and Non-Thesis Options): *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 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 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.

Additionally, students are asked to complete a survey near the end of their MS program to self-evaluate how well they feel they met the Student Learning Outcomes for the MS program. In addition to the survey, the student is required to compose a brief description of how a project or projects completed during the course of their program serves to

demonstrate their ability to analyze, design, and implement a computing system. The written description and survey are used to gather program-level assessment data. A rubric is used to evaluate a student's written description. The completed survey and written description are returned to the CSE Graduate Advisor, who archives this data. At the end of the spring semester, the surveys and written descriptions are provided to the ECE department head, who ensure the written descriptions are evaluated. The results of the surveys and descriptions will be organized and formatted over the summer. During the following academic year, the Graduate Studies Committee reviews the direct measures (written descriptions) and the indirect measures (student surveys) and then make recommendations for changes in response to the findings. Once each year, the summarized data, and proposed changes, if any, are reviewed and discussed by the ECE faculty.	
Measures: Rubrics will be used for the specific graded student projects in a given 5xx 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 computer science and engineering knowledge. Student surveys and program written description are also collected and evaluated to determine the overall program outcomes as students exit the program.	
Learning Outcome #2 (Thesis Option): *Critically analyze published research results in 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 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 the student's computer science and engineering related research project and written thesis under the guidance of a faculty advisor. The thesis is reviewed by an examining committee consisting of at least 3 faculty (2 of which must be Graduate Faculty) from the ECE department and chaired by the faculty advisor prior to the student conducting an oral presentation/defense of their thesis. The outcome will also be assessed in specific research-oriented assignments from CSE 507 coursework.	
Measures: This outcome will be measured by **i**nstructor grading of research related coursework in CSE 507. It will also be assessed by the student's written thesis and oral	

defense using the collective results of a Program Assessment Survey completed by all thesis committee members.	
Learning Outcome #3 (Thesis Option): *Conduct original research on a significant computer science and engineering problem.*	
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 thesis that will be defended orally before a faculty thesis committee.	
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 thesis committee will assess the originality, merit, and contributions of the candidate's research. The written thesis and oral defense is facilitated by a faculty committee consisting of at least 3 faculty (2 of which must be graduate faculty) from the ECE department and chaired by the faculty advisor. All members of the thesis committee will be asked to complete a Program Assessment Survey, and the results will be culminated together to form an overall assessment of the student's thesis.	
Measures: Evaluation of the student's final written thesis. The thesis 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 computing theory and methods, and (c) interpret and communicate research ideas, data and findings.	
Learning Outcome #4 (Thesis and Non-Thesis Options): ***C****ommunicate (written & oral) and defend results of projects or research to peers and broader engineering audiences.*	
Concepts: Utilize acquired computer science and engineering skills and knowledge to communicate effectively in both written and oral mediums. This may be accomplished in a variety of methods including presenting the results of software / computing related projects to peers, faculty, and potentially industry experts. Additionally, students that opt for the *Thesis-Option* will prepare a written thesis 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. *Thesis* students will also be required to present their research findings in an oral defense of their project / research.	
Competencies: Demonstrate their ability to articulate all aspects of product development and/or research in a computer science and engineering specialization area. Students opting for the course work only option of the degree program, will describe the relevant design or implementation details of projects that they have developed/implemented, describe methodologies used in developing computing products, and demonstrate designs and/or working products. Students opting for the *Thesis-Option* of the degree program will also describe and defend the significance of their projects / research in a thesis, describe the methodologies used in conducting the computer science and engineering related research, and summarize their overall findings resulting from said research in written and oral mediums.	
Assessment Methods: For all CSE students, specific project rubrics will be used for the specific graded student project for a given course that clearly evaluates the learning objectives and outcomes of the projects that students are asked to complete. All rubrics are developed by faculty members with expertise in associated 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. Additionally, for *Thesis-Option* students, a thesis committee will assess the originality, merit, and contributions of the candidate's research. The written thesis and oral defense is facilitated by a faculty committee appointed consisting of at a minimum 3 faculty from the ECE departments and chaired by the faculty advisor.	
Measures: For all students, rubrics will be used for specific graded student projects in a given 5xx 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 computer science and engineering knowledge. For *Thesis-Option* students, evaluation of the student's final written and oral thesis. The thesis 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 engineering theory and methods, and (c) interpret and communicate research ideas and findings.	
Learning Outcome #2 (Non-Thesis Option): *Analyze a computing system related to computer science and engineering.*	
Concepts: Derive, develop and analyze the algorithms, design, and implementation for a computing system / subsystem. Additionally, students will also develop plans and procedures that verify/validate the correct implementation and performance of the specified product. Students will also evaluate whether a software implementation meets its associated requirements as specified.	
Competencies: Evaluate, analyze and implement computing algorithm(s), products and/or other computing solutions to meet a specified problem statement. Students will derive, develop and analyze the implementation and performance requirements for a specific computing product / system / subsystem. Students will also analyze / evaluate how well the computing solution meets its intended use/requirements.	
Assessment Methods: This outcome will be assessed predominately through implementation and/ or evaluation of computing product that meets a given or derived specification for a software / computing product. Midterm and final exams that test the students comprehension of the computer science and engineering concepts taught and competencies acquired will also be used. Rubrics will be created that identify 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 project artifacts for a given course will be evaluated and assessed. 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: Instructor grading of course exams and computing projects for each course that contributes to this outcome. Rubrics will be used to measure the specific project evidence for each course. Descriptions that clearly measure the given evidence are used to assign the students achievement level. The achievement levels for the rubrics include: "Exemplary", Satisfactory", "Developing", and "Unsatisfactory". Student surveys and program written description are also collected and evaluated to determine the overall program outcomes as students exit the program.	
Learning Outcome #3 (Non-Thesis Option): *Design and implement a computing system in a related computer science and engineering discipline based on given specifications.*	
Concepts: Use industry best practices, methods, and tools in architecting, modeling, and designing computing systems. Students also investigate and evaluate the importance of developing a sound computing architecture and design as part of the evolution of the implementation of a computing system/product. Working in teams on larger-scale semester projects, students implement their designs and show the traceability between specifications, computing design, and the resulting implementation for a specified computing system/product.	
Competencies: Architect/design specified software/computing products for diverse applications including mobile, cloud, embedded, or other computing applications. Students will collaborate with other students and CSE advisors to complete projects using modern modeling tools and methodologies (i.e., UML or equivalent). Students will also implement/develop their designs for a variety of computing-based products. Students will present/review their designs and implementations in a professional setting with other CSE students, faculty and industry professionals.	
Assessment Methods: This outcome will be assessed predominately through implementation of a semester project that meets a given specification for a software / computing-based product. Midterm and final exams that test the students comprehension of the engineering concepts taught and competencies acquired will also be used. Rubrics will be created that identify 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 project artifacts for a given course will be evaluated and assessed. 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 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: Instructor grading of course exams and computing projects for each course that contributes to this outcome. Rubrics will be used to measure the specific project evidence for each course. Descriptions that clearly measure the given evidence are used to assign the students achievement level. The achievement levels for the rubrics include: "Exemplary", Satisfactory", "Developing", and "Unsatisfactory". Student surveys and program written description are also collected and evaluated to determine the overall program outcomes as students exit the program.

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.

MS Computer Science and Engineering
Courses and Activities Mapped to MS Computer Science and Engineering

	Outcome					
	SLO 1 Demonstrate broad knowledge in his/her field in Computer Science and Engineering.	SLO 2: Non-Thesis Option Analyze a computing system or a subsystem related to computer science engineering.	SLO 2:Thesis Option Critically analyze published research results in his/her area of study.	SLO 3: Non-Thesis Option Design and implement a computing system in a computer science engineering area based on given specifications.	SLO 3: Thesis Option Conduct original research on a significant computer science engineering problem.	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	P/A	P/A		P/A		
CSE 502 Compiler Design	P/A	P/A		P/A		
CSE 503 Analysis of Algorithms for Engineering Applications	P/A	P/A		P/A		P/A
CSE 504 Embedded Systems Computing	P/A	P/A		P/A		
CSE 505 Advanced Data Structures	P/A	P/A		P/A		
CSE 506 Database Engineering	P/A	P/A		P/A		
CSE 507 Computer Science and Engineering Research Methods			IPA		IPA	P/A
CSE 910 Thesis			IPA		IPA	IPA
Exit Survey Exit survey (Indirect)	A	A	A	A	A	A

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

MS Thesis Students

The Computer Science and Engineering (CSE) MS Thesis Option program requires a student complete an oral defense of their thesis. The student also completes a survey near the end of their MS program to self-evaluate how well they feel they met the Student Learning Outcomes for the MS program. The thesis defense and survey are used to gather program-level assessment data.

A rubric to evaluate a student's thesis work has been developed by the ECE/CSE faculty. Each faculty committee member completes the rubric at the end of the oral thesis defense. These completed rubrics are returned to the ECE/CSE Graduate Advisor, who archives this data. At the end of the Spring semester, the completed rubrics and surveys and provided to the ECE Department Head and /or Associate Department Head, who

organize and formats the results during the summer. During the following academic year, the Graduate Studies Committee reviews the direct measures (thesis rubrics) and the indirect measures (student surveys) and then makes recommendations for changes in response to the findings. Once each year, the summarized data, and proposed changes, if any, are reviewed and discussed by the CSE faculty.

MS Non-Thesis Students

The Computer Science and Engineering (CSE) MS Non-Thesis Option program requires a student to complete 30 units of graduate coursework. This coursework has limitations as described in the CSE Graduate Handbook. The student completes a survey near the end of their MS program to self-evaluate how well they feel they met the Student Learning Outcomes for the MS program. In addition to the survey, the student is required to compose a brief description of how a project or projects completed during the course of their program served to demonstrate their ability to analyze, design, and implement a CSE-related system. The written description and survey are used to gather program-level assessment data.

A rubric is used to evaluate a student's written description. The completed survey and written description are returned to the ECE/CSE Graduate Advisor, who archives this data. At the end of the spring semester, the surveys and written descriptions are provided to the ECE Department Head and /or Associate Department Head, who makes sure the written descriptions are evaluated and then organizes and formats the results of the written descriptions and surveys during the summer. During the following academic year, the Graduate Studies Committee reviews the direct measures (written descriptions) and the indirect measures (student surveys) and then makes recommendations for changes in response to the findings. Once each year, the summarized data, and proposed changes, if any, are reviewed and discussed by the CSE faculty.

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.
MS final written thesis *(Thesis-Option only)*	Written thesis	Written and evaluated at the conclusion of the student's thesis efforts to assess the merit and contributions of the student's research and findings.
Thesis oral presentation / defense (*Thesis-Option* only)	Oral presentation / defense of the student's thesis	At the completion of the thesis, the student will present their work to a faculty thesis committee and

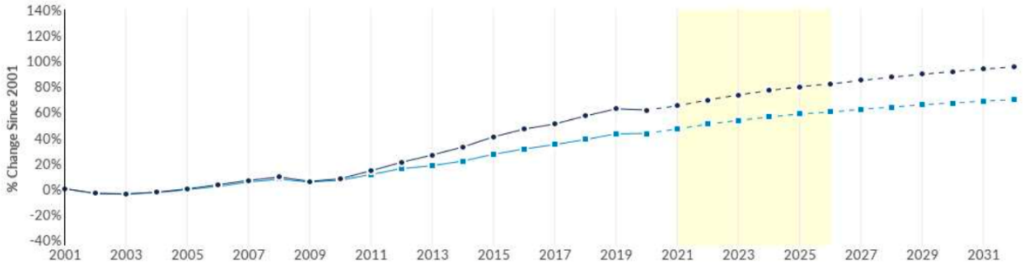
		answer any general questions related to their work
Graduation exit survey (used for indirect measures of outcomes).	Student survey	At student graduation
Academic Program Review	APR reviewer evaluation responses	Minimum of every 7 years
Data from continuous improvement implementation efforts (recommended by the Graduate Studies Committee (GSC))	Assessment data	At the end of an academic year

Projected Enrollment for the First Three Years:
Please provide anticipated enrollment numbers for each of the first three years of the proposed program

Degree	Year 1 (2024 / 2025)	Year 2 (2025 / 2026)	Year 3 (2026 / 2027)
MS	10	30	60

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%

[1] Emsi Q2 2022 Data Set, www.economicmodeling.com

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 MS and PhD degree programs will serve both local, state, and national needs related to employment, economic development, and national security. Indeed, these degree programs are among the most important in support of the ongoing fourth industrial revolution and in close alignment with Arizona's New Economy Initiative[2].

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

Similar Programs Offered at Arizona Public Universities:

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

Objection(s) Raised by Another Arizona Public University? YES NO
Has another Arizona public university lodged a written objection to the proposed program with the proposing university and the Board of Regents within seven days of receiving notice of the proposed program?

If Yes, Response to Objections:
Please provide details of how the proposing university has addressed the objection. If the objection remains unresolved, please explain why it is in the best interests of the university system and the state that the Board override it.

New Resources Required? (i.e., faculty and administrative positions; infrastructure, etc.):

Resources	Quantity
Faculty	**8**
Staff	**2**
Other (TAs, RAs, Graders, LAs) *(Semester hires over next 5 academic years)*	• 12 Teaching Assistants or Research Assistants (TAs / RAs) *(total over next 5 years)*

[2] World Economic Forum. https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

	• 0 Graders • 0 LAs
Equipment	• New research and lab equipment is included in the startup packages for new TT faculty
Facilities	• Office and lab space *(for new faculty)*

Plan to Request Program Fee/Differentiated Tuition? NO

Estimated Amount: N/A

Program Fee Justification: N/A
If planning to levy a program fee, please justify the estimated amount.

Note: The fee setting process requires additional steps, and forms need to be completed. Please work with your university and the ABOR Finance team (Leatta.McLaughlin@azregents.edu) to complete a fee request.

Specialized Accreditation? NO

Accreditor: N/A