ARIZONA STATE UNIVERSITY
PROPOSAL TO ESTABLISH A NEW GRADUATE DEGREE

This template is to be used only by programs that have received specific written approval from the Provost's office to proceed with internal proposal development and review. A separate proposal must be submitted for each individual new degree program.

DEGREE PROGRAM

College/School(s) offering this degree: Fulton Schools of Engineering

Unit(s) within college/school responsible for program: School of Computing, Informatics and Decision Systems Engineering, School of Electrical, Computer and Energy Engineering

If this is for an official joint degree program, list all units and colleges/schools that will be involved in offering the degree program and providing the necessary resources: School of Computing, Informatics and Decision Systems Engineering (housing Computer Systems concentration), School of Electrical, Computer and Energy Engineering (housing Electrical Engineering concentration)

Proposed Degree Name: Doctor of Philosophy in Computer Engineering

Doctoral Degree Type: PhD-Doctor of Philosophy

Proposed title of major: Computer Engineering

Is a program fee required? Yes ☒ **No** ☐

Requested effective term: Select term and year: Fall 2011
(The first semester and year for which students may begin applying to the program.)

PROPOSAL CONTACT INFORMATION

(Person to contact regarding this proposal)

Name: Sandeep Gupta
Joseph Palais
Phone:480-956-2794,
480-965-6410

Title: Professor
Professor
email: joseph.palais@asu.edu
email: sandeep.gupta@asu.edu

DEAN APPROVAL

This proposal has been approved by all necessary unit and College/School levels of review, and the College/School(s) has the resources to offer this degree program. I recommend implementation of the proposed degree program. (*Note: An electronic signature, an email from the dean or dean's designee, or a PDF of the signed signature page is acceptable.*)

College Dean Name: ***(Please see attached Curriculum Planning email submission) 10/19/10***

College Dean Signature _____ **Date:** _____

College Dean name:
(If more than one college involved)
College Dean Signature _____ **Date:** _____

ARIZONA STATE UNIVERSITY
PROPOSAL TO ESTABLISH A NEW GRADUATE DEGREE

This proposal template should be completed in full and submitted to the University Provost's Academic Council [mailto:curriculum@asu.edu]. It must undergo all internal university review and approval steps including those at the unit, college, and university levels. A program **may not** be implemented until the Provost's Office notifies the academic unit that the program may be offered.

DEGREE PROGRAM INFORMATION

Doctoral: Doctor of Philosophy

Proposed title of major: Computer Engineering

1. PURPOSE AND NATURE OF PROGRAM

A. Brief program description (This is a catalog type description of no more than 250 words. Include the distinctive features of the program that make it unique. Do not include program or admission requirements.)

Today, computing systems are no longer limited to desktop machines or mainframes. Computers are embedded in nearly every space that we inhabit and in many places that we do not. They now involve not only computation, but also multi-modal sensing, signal processing, communications, and control. Moreover, functions that were previously considered to be strictly software or strictly hardware can no longer be distinguished in that way. Software and hardware have completely merged.

Computer Science focuses on the theory of computation including the study of their complexity, the development of efficient algorithmic techniques for manipulating information, and the implementation of the algorithms in software. Computer Engineering on the other hand is concerned with ways that the science of computation is applied to building devices, components and systems that perform the computation. It considers the design, analysis and optimization of *systems* that span nearly 10 orders of magnitude in scale – from components that are billionths of a meter in size to systems that occupy hundreds of square meters such as datacenters.

Computer Engineering is a multi-disciplinary program that builds on the fundamentals of Computer Science, Electrical Engineering, Industrial Engineering and Applied Mathematics. Graduates of this program will have the knowledge and skills necessary to fundamentally advance and develop new paradigms for the design, system integration, testing, evaluation and deployment of state-of-the-art hardware and software for systems that include computing, communications and networking (wired and wireless), control functions, sensing, signal processing and actuation. The PhD program is intended for students with excellent ability in mathematics and physical science that are interested in gaining an in-depth knowledge of the foundational principles of engineering and pursuing a career in academia, research or highly technical entrepreneurial innovation. The PhD program provides a broader and more in-depth preparation than the MS and MSE programs in anticipation of a demonstrated ability to independently pursue more creative and substantive innovation with higher impact.

B. Total credit hours required for the program: 84

C. Are any concentrations to be established under this degree program? ☒ Yes ☐ No

i. If "Yes", please check one:
- ☒ Students must select a concentration as part of this degree program
- ☐ Concentrations are optional

ii. If "Yes", list the name of the concentrations and the minimum number of credit hours required for each concentration.

Concentration Name	Number of credit hours for courses specific to the concentration
Electrical Engineering	18
Computer Systems	18

2. PROGRAM NEED. Explain why the university needs to offer this program (include data and discussion of the target audience and market).

The proposed Ph.D program in Computer Engineering provides job learning and training for advanced students in technology areas critical to the regional economy associated with the computer and microelectronics industry. The proposed graduate program in Computer Engineering was structured based on the trajectory of computer related hardware and software technologies, and the resulting workforce needs of the state and the nation.

The proposed program will include in-depth courses in computer engineering with a balanced exposure to hardware and software. Students with a graduate degree Computer Engineering can reap the financial benefits of the growing job market in that field, as forecasts call for continued demand for new computer engineers. Students with a Ph.D in Computer Engineering have additional options for high paying jobs, including academic positions, government and industrial research centers, and senior engineering positions in industry.

The target market for our graduates and companies in Arizona can be classified into two main categories:

Component manufacturers: The key components that are integrated into a modern computer system include: system software, integrated circuits (IC) and boards. The worldwide market for these three components was estimated at $45 billion in the year 2004 and is expected to grow at an impressive annual rate of 14%. Significant players with major presence in the State of Arizona in the computing system component market (in particular embedded ICs) include Intel, IBM, Motorola, Microchip, ON semiconductors, Freescale, NXP and Marvell Technology.

System integrators: The computing system components are integrated into finished end products by system integrators. The State of Arizona is home to several major electronic control system integrators that cater to the aerospace/defense market. These companies include Honeywell, Raytheon, Boeing, and General Dynamics. According to a 2003 Defense News report, the 2002 worldwide market for defense-related aerospace totaled $197.4 billion. The same year, the top six defense contractors (Boeing, Raytheon, General Dynamics, Lockheed Martin, BAE Systems (UK-based), and Northrop Grumman) controlled 49.5 percent of the total global defense market sales.

The profound economic impact of these industries has been recognized by the Arizona Department of Commerce in their economic report of advanced communication and information technology (AC-IT) industry. The AC-IT industry includes both the computing system component manufacturers (denoted as primary industry in the report) and system integrators (denoted by embedded AC-IT industry in the report). AC-IT related jobs pay 75% more than the average state salary, and account for more than 9% of the total employment in the private sector in AZ. Further more, the AC-IT industry accounted for over $6B in Arizona foreign export out of a total export of $11B.

The U.S. Labor Department expects the demand for computer engineers will continue to remain strong. Arizona has an ever-increasing demand for computer engineers. But, no state university in Arizona offers a Masters and a Ph.D degree in computer engineering. Therefore, Arizona State University should increase the number of computer engineers with graduate degrees or face the loss of technology jobs to other states because there is a shortage of computer engineers. The proposed PhD program in computer engineering will serve the needs of Valley and national organizations for highly talented, high tech innovators and provide a talent pool for generating new economic development.

3. IMPACT ON OTHER PROGRAMS. List other academic units that might be impacted by the proposed program and describe the potential impact (e.g., how the implementation of this program might affect student headcount/enrollment, student recruitment, faculty participation, course content, etc. in other programs). Attach letters of collaboration/support from impacted programs.

At present, School of Computing, Informatics and Decision Systems Engineering (SCIDSE) offers graduate degrees (MS and Ph.D) only in Computer Science and Industrial Engineering, and the School of Electrical, Computer and Energy Engineering (SECEE) only in Electrical Engineering. The proposed Ph.D program, being a joint program of SCIDSE and SECEE, will have a significant positive impact on both schools. Neither the Computer Science nor the Electrical Engineering graduate programs adequately train students in subject areas of Computer Engineering. Students interested in pursuing a graduate degree in Computer Engineering are forced to cobble together a collection of courses in Computer Science, Electrical Engineering, Industrial Engineering, and Mathematics to gain the requisite background to undertake research in Computer Engineering. The proposed program provides a proper definition and structure to Computer Engineering. It establishes a set of core courses that are essential to every computer engineer, and builds on that core curriculum with a well chosen subset of courses from the various related areas mentioned above. As a result, it is expected to draw many more students to ASU, who otherwise would go to peer institutions in other states, most of which have graduate programs in Computer Engineering.

4. PROJECTED ENROLLMENT How many new students do you anticipate enrolling in this program each year for the next five years? Please utilize the following tabular format.

5-YEAR PROJECTED ANNUAL ENROLLMENT					
	1st Year	**2nd Year** (Yr 1 continuing + new entering)	**3rd Year** (Yr 1 & 2 continuing + new entering)	**4th Year** (Yrs 1, 2, 3 continuing + new entering)	**5th Year** (Yrs 1, 2, 3, 4 continuing + new entering)
Number of Students Majoring (Headcount)	20	40	60	80	90

5. STUDENT LEARNING OUTCOMES AND ASSESMENT

A. List the knowledge, competencies, and skills students should have when they graduate from the proposed degree program. (You can find examples of program Learning Outcomes at (http://www.asu.edu/oue/assessment.html).

Doctoral Degree Learning Outcomes (Dissertation required):

Outcome 1: Students completing the Doctor of Philosophy in Computer Engineering will be able to analyze and synthesize key theories and methods used in the field of computer engineering.

Outcome 2: Students completing the Doctor of Philosophy in Computer Engineering will be able to generate and evaluate new theories, methods and designs that can advance the field of computer engineering.

Outcome 3: Students completing the Doctor of Philosophy in Computer Engineering will be able to effectively communicate and disseminate the results of their research study orally and in writing.

B. Describe the plan and methods to assess whether students have achieved the knowledge, competencies and skills identified in the Learning Outcomes. (You can find examples of assessment methods at (http://www.asu.edu/oue/assessment.html).

Outcome 1: Students completing the Doctor of Philosophy in Computer Engineering will be able to analyze and synthesize key theories and methods used in the field of computer engineering.

Assessment Measure 1: (Direct measure) Students will be assessed on their ability to analyze and synthesize key theories and methods of computer engineering through oral and written comprehensive exams prepared by an appointed committee of program faculty members. Satisfactory program performance is indicated when more than 80% of the students satisfactorily demonstrate this mastery on their first attempt on the examinations.

Assessment Measure 2: (Indirect measure) Students will be employed in an area utilizing the knowledge acquired in the degree program and demonstrating analysis and synthesis capability. Satisfactory program performance is indicated when more than 80% of the students completing the program are appropriately employed within two years of graduation in a position that requires analysis, synthesis, and/or evaluation of computer engineering theories and methods with a continuing appointment or satisfactory performance review..

Outcome 2: Students completing the Doctor of Philosophy in Computer Engineering will be able to generate and evaluate new theories, methods, and designs that can advance the field of computer engineering.

Assessment Measure 1: (Direct measure) Students will select a topic for research, perform preliminary scholarly research on that topic, and successfully defend a dissertation proposal on that topic before an appointed committee of program faculty. Satisfactory program performance is indicated when more than 80% of the students meet this outcome on the first attempt.

Assessment Measure 2(Direct measure). Students will complete a research study as outlined in their proposal and document their original contribution for submission to an approval by an appointed committee of program faculty. Satisfactory program performance is indicated when more than 85% of the students meet this outcome on the first attempt.

Outcome 3: Students completing the Doctor of Philosophy in Computer Engineering will be able to effectively communicate and disseminate the results of their research study orally and in writing.

Assessment Measure 1: Students will present an open oral defense of their dissertation research to an audience of knowledgeable researchers and satisfactorily respond to questions. Satisfactory performance is met when more than 85% of the students have received an award for a conference presentation by the time of graduation or have passed the oral defense of the dissertation on the first attempt.

Assessment Measure 2: : (Indirect measure) Students will publish (or have accepted for publication) at least one journal paper published in a recognized journal at the time of graduation. Satisfactory program performance is indicated when 80% of the students meet this outcome at the time of the dissertation defense.

6. ACCREDITATION OR LICENSING REQUIREMENTS (if applicable). Provide the names of the external agencies for accreditation, professional licensing, etc. that guide your curriculum for this program, if any. Describe any requirements for accreditation or licensing.

NONE

7. FACULTY, STAFF AND RESOURCE REQUIREMENTS

A. Faculty

i. Current Faculty. List the name, rank, highest degree, area of specialization/expertise and estimate of the level of involvement of all current faculty who will teach in the program.

Surname	Given Name	Rank	Degree	Expertise	% involvement
Ahn	Gail-Joon	Assoc. Prof	Ph.D	Network security	10%
Askin	Ronald	Prof.	Ph.D	Applied optimization	5%
Candan	Kasim (Selcuk)	Prof	Ph.D	Database systems	10%

Cao	Yu (Kevin)	Asst. Prof	Ph.D	Nanoscale modeling	10%
Chakrabarti	Chaitali	Prof	Ph.D	VLSI architecture	25%
Chatha	Karam	Assoc. Prof	Ph.D	Embedded systems	25%
Baral	Chitta	Prof	Ph.D	Autonomous agents	10%
Clark	Larry	Assoc. Prof	Ph.D	Low power electronics	10%
Colbourn	Charles	Prof.	Ph.D	Network reliability	10%
Dasgupta	Partha	Assoc. Prof	Ph.D	Security & Op. systems	10%
Vasileska	Dragica	Prof	Ph.D	Semiconductor devices	10%
Fainekos	Georgios	Asst. Prof	Ph.D	Cyber physical systems	25%
Fowler	John	Prof.	Ph.D	Scheduling theory	10%
Gel	Esma	Assoc. Prof	Ph.D	Stochastic modeling	10%
Gupta	Sandeep	Prof	Ph.D	Cyber-physical systems	25%
Huang	Dijiang	Asst. Prof	Ph.D	Network security	10%
Hui	Joseph	Prof	Ph.D	Wireless networks	10%
Kambhampati	Subbarao	Prof	Ph.D	Automated planning	10%
Karam	Lina	Prof	Ph.D	Signal/Image processing	25%
Kim	Seungchan	Prof.	Ph.D	Signal processing	10%
Tsakalis	Konstantinos	Prof	Ph.D	System optimization	10%
Lee	Yann-Hang	Prof	Ph.D	Real-time systems	20%
Li	Baoxin	Asst. Prof	Ph.D	Multimedia processing	10%
Li	Jing	Prof.	Ph.D	Statistical modeling	10%
Mirchandani	Pitu	Prof.	Ph.D	Real-time control	10%
Palais	Joseph	Prof	Ph.D	Optical communications	10%
Panchanathan	Sethuraman	Prof.	Ph.D	Ubiquitous computing	10%
Phillips	Stephen	Prof	Ph.D	Microelectrical systems	10%
Reisslein	Martin	Assoc. Prof	Ph.D	Fiber/wireless networks	25%
Richa	Andrea	Assoc. Prof	Ph.D	Network optimization	10%
Runger	George	Prof.	Ph.D	Data mining	10%
Sen	Arunabha	Prof	Ph.D	Network optimization	10%
Shrivastava	Aviral	Asst. Prof	Ph.D	Multicore architecture	25%
Si	Jennie	Prof	Ph.D	Nonlinear dynamic systems	10%
Spanias	Andreas	Prof	Ph.D	Digital signal processing	10%
Sundaram	Hari	Assoc. Prof	Ph.D	Multimedia & databases	10%
Syrotiuk	Violet	Assoc. Prof	Ph.D	Mobile ad hoc networks	10%
Tsai	Wei-Tek	Prof.	Ph.D	Software engineering	10%
Vrudhula	Sarma	Prof.	Ph.D	VLSI circuit design	25%
Wonka	Peter	Asst. Prof	Ph.D	Computer graphics	10%
Xue	Guoliang	Prof.	Ph.D	QoS routing & security	10%
Zhang	Yanchao	Assoc. Prof	Ph.D	Network security	10%
Yau	Stephen	Prof	Ph.D	Cyber security	10%
Zhang	Junshan	Prof	Ph.D	Wireless networks	10%
Zhang	Muhong	Asst. Prof	Ph.D	Robust optimization	10%

ii. **New Faculty.** Describe the new faculty hiring needed during the next three years to sustain the program. List the anticipated hiring schedule and financial sources for supporting the addition of these faculty.

Additional faculty needs will be met through the regular faculty hiring process in the two participating schools.

iii. **Administration of the program.** Explain how the program will be administered for the purposes of admissions, advising, course offerings, etc. Discuss the available staff support.

A Computer Engineering Graduate Program (CEGP) faculty will be formed, consisting of faculty participating in the program from SCIDSE and SECEE. It will be led by a chair.

Two new courses will be added to provide a common background in fundamentals of computer systems. The rest of the curriculum, at least in the initial stages of the proposed program, will be based on existing courses in the SCIDSE and SECEE. The CEGP faculty can support the teaching load. Additional faculty needs will be met through the regular faculty hiring process in the two participating schools. We expect that most of the classes for the proposed program will be taught by ranked faculty.

The established procedures for admissions to the Ph.D program in EEE and CS will be followed for admissions to the proposed Ph.D program in Computer Engineering.

Admissions will be carried out by a committee from the CEPG faculty. The responsibility of advising students will be distributed among the CEGP faculty. Every student will have a faculty advisor from the CEGP faculty.

The graduate support staff of each school will handle the paperwork for their respective concentrations including correspondence with prospective students, preparing applications for review by the admissions committee, corresponding with the graduate college on admissions, filing programs of study, and reporting exam results, .

B . Resource requirements to launch and sustain the program. Describe any new resources required for this program's success such as new staff, new facilities, new library resources, new technology resources, etc

Existing resources in the two participating schools, SCIDSE and SECEE, will be utilized to administer the proposed program.

The two participating schools will be responsible for all financial activities of the proposed program. Research and Teaching Assistant positions will be available on the same basis as is done for other graduate programs in Computer Science and Electrical Engineering.

Laboratory equipment for the proposed program is adequate at this stage and will be updated on occasion. Plans will be made to assure that the program's laboratories remain competitive and versatile.

No additional library acquisitions are needed as most of our literature access is done electronically.

8. CURRICULAR STRUCTURE OF THE PROPOSED PROGRAM

A. Admission Requirements The requirements listed below are Graduate College requirements. Please modify and/or expand if the proposed degree has additional admissions requirements.

i. Degree. Minimum of a bachelor's degree (*or equivalent*) or a graduate degree from a regionally accredited College or University of recognized standing in a related field such as:

Computer Engineering, Computer Systems Engineering, Electrical Engineering, and Computer Science.

ii. GPA. Minimum of a 3.00 cumulative GPA (scale is 4.0=A) in the last 60 hours of a student's first bachelor's degree program. A minimum GPA of 3.0 is required in the MS/MSE work for acceptance into the Ph.D. program.

iii. English Proficiency Requirement for International Applicants. If applicable list any English proficiency requirements that are higher than and/or in addition to the Graduate College requirement. (See Graduate College policy and procedures http://graduate.asu.edu/admissions/international.html#proficiency): Same as Graduate College requirement

iv. Required Admission Examinations.
☐GRE** ☐GMAT ☐Millers Analogies ☐None Required

**Please note: Students (*International and Domestic*) are exempt from taking the GRE who have degrees from any ABET accredited program (*from US or overseas institutions)* and meet the minimum GPA requirements of the academic units. Students, who do not meet these requirements as outlined, will be required to take the GRE.

v. Application Review Terms. Indicate all terms for which applications for admissions are accepted and the corresponding application deadline dates, if any:

☒ Fall Deadline (month/year): March/2011 (and every Feb thereafter)

☒ Spring Deadline (month/year): August/2011 (and every August thereafter)

☐ Summer Deadline (month/year):

B. Degree Requirements. Below provide the curricular requirements for the proposed degree program.

i. *Total credit hours (cr hrs) required for the degree program*: 84

ii. Core courses. List all required core courses and total credit hours for the core (required courses other than internships, thesis, dissertation, capstone course, etc)**.** Omnibus number courses cannot be used as core courses. Permanent numbers must be requested by submitting course proposal to ACRES for approval.

***Total cr hrs for required core courses*: 6 cr hrs**

Required Core courses:

Course prefix & number	Course title	Credit hours	New course?
CEN501	Computer Systems I: Circuits to Architectures	3	Y ☒ N ☐
CEN502	Computer Systems II: Fundamentals of Algorithms and Optimization Techniques	3	Y ☒ N ☐

The combination of CEN501 and CEN502 serves to integrate the required knowledge of electrical engineering and computer science to ensure that all students have the necessary background to pursue advanced study in the areas of computer engineering. CEN501 focuses on circuit and logic design, topics that span the electrical engineering to computer engineering interface. CEN502 begins with computer architecture and focuses on operating systems, compilers, and networking topics that cover the computer science to computer engineering interface. Together this pair of courses provides a common and necessary background for all students in the program to pursue further advanced study in the six areas of the program. As such, these courses must be taken early in the student's course of graduate study.

iii. Elective Courses

***Total cr hrs for program electives:* minimum of 42 cr hrs**

The elective courses in the graduate Computer Engineering program are partitioned into six (6) areas study, and listed in the table below. These courses will be referred to as Computer Engineering Area (CE-Area) courses.

The six (6) areas of study are:

1. VLSI and Architecture
2. Embedded Control Systems
3. Communication and Networks
4. Distributed, Dependable and Secure Systems
5. Multimedia and Signal Processing
6. Systems Optimization

Requirements:

At least **24 credit hours** of CE-Area courses are needed to provide a breadth of knowledge in CE to support an extensive research and dissertation experience.

At least **18 credit hours** of **other graduate** courses
(Graduate courses in Science, Engineering, or Mathematics with the approval of the Computer Engineering Graduate Committee). These courses are intended to provide a level of breadth and depth in basic science and analytical methods well beyond that required for the Masters level.

The above CE area courses must satisfy the following constraints:

At most **6 credit hours** of **M***
At least **12 credit hours** of **M* or D***

Remaining credit hours can be **other** graduate courses
(Graduate courses in Science, Engineering, or Mathematics with the approval of the Computer Engineering Graduate Committee).

The following list of courses will be referred to as Computer Engineering Courses

1. VLSI and Architecture

Course prefix & number	**Course title**	**Credit hours**	**New course?**
CSE 420/598	Computer Architecture I **(M*)**	3	Y ☐ N ☒
EEE 425/591	Digital Circuits and Systems **(M*)**	4	Y ☐ N ☒
CSE 520	Computer Architecture II **(D*)**	3	Y ☐ N ☒
EEE 525	VLSI Design **(D*)**	3	Y ☐ N ☒
EEE 526	VLSI Architectures	3	Y ☐ N ☒
EEE 625	Advanced VLSI design	3	Y ☐ N ☒
CSE 591	Digital Logic Synthesis and Verification Algorithms	3	Y ☐ N ☒
CSE 591	VLSI CAD 1	3	Y ☐ N ☒
CSE 598	System-level Hardware/Software Co-design	3	Y ☐ N ☒
CSE 591	Low Power Architectures	3	Y ☐ N ☒
CSE 591	Formal Methods for System Verification	3	Y ☐ N ☒

2. Embedded Control Systems

Course prefix & number	Course title	Credit hours	New course?
EEE 480/591	Feedback Systems **(M*)**	4	Y ☐ N ☒
EEE 481/591	Computer Controlled Systems **(M*)**	3	Y ☐ N ☒
EEE585	Digital Control Systems **(D*)**	3	Y ☐ N ☒
CSE591	Introduction to Hybrid Systems **(D*)**	3	Y ☐ N ☒
CSE574	Planning and Learning Methods in AI	3	Y ☐ N ☒
EEE582	Linear System Theory	3	Y ☐ N ☒
EEE586	Nonlinear Control Systems	3	Y ☐ N ☒
EEE587	Optimal Control	3	Y ☐ N ☒
EEE588	Design of Multivariable Control Systems	3	Y ☐ N ☒
EEE686	Adaptive Control	3	Y ☐ N ☒
EEE511 CSE591	Artificial Neural Computation **OR** Machine Learning	3	Y ☐ N ☒

3. Communications and Networks

Course prefix & number	Course title	Credit hours	New course?
CSE 434/598 EEE 459/591	Computer Networks, or **(M*)** Communication Networks **(M*)**	3	Y ☐ N ☒
EEE 455/591	Communication Systems **(M*)**	3	Y ☐ N ☒
CSE 534	Advanced Computer Networks **(D*)**	3	Y ☐ N ☒
EEE 551	Information Theory **(D*)**	3	Y ☐ N ☒
CSE 468/598	Computer Network Security	3	Y ☐ N ☒
CSE 535	Mobile Computing	3	Y ☐ N ☒
EEE552	Digital Communications	3	Y ☐ N ☒
EEE553	Coding and Cryptography	3	Y ☐ N ☒
EEE557	Broadband Networks	3	Y ☐ N ☒
EEE558	Wireless Communications	3	Y ☐ N ☒
EEE607	Speech Coding for Multimedia Communications	3	Y ☐ N ☒

4. Distributed, Dependable and Secure Systems

Course prefix & number	Course title	Credit hours	New course?
CSE 430/598	Operating Systems **(M*)**	3	Y ☐ N ☒
CSE 440/598	Compiler Construction I **(M*)**	3	Y ☐ N ☒
CSE 522	Real Time Embedded Systems **(D*)**	3	Y ☐ N ☒
CSE531	Distributed and Multiprocessor Operating Systems **(D*)**	3	Y ☐ N ☒

CSE 412/598	Database Management	3	Y ☐ N ☒
CSE 445	Distributed Software Development	3	Y ☐ N ☒
CSE 565	Software Verification, Validation and Testing	3	Y ☐ N ☒
CSE 543	Information Assurance and Security	3	Y ☐ N ☒
CSE 512	Distributed Database Systems	3	Y ☐ N ☒
CSE 545	Software Security	3	Y ☐ N ☒
CSE 539	Applied Cryptography	3	Y ☐ N ☒

5. Multimedia and Signal Processing

Course prefix & number	**Course title**	**Credit hours**	**New course?**
EEE 407/591	Digital Signal Processing **(M*)**	4	Y ☐ N ☒
EEE 404/591	Real-Time Digital Signal Processing **(M*)**	4	Y ☐ N ☒
EEE 554	Random Signal Theory **(D*)**	3	Y ☐ N ☒
EEE 508 or CSE 509	Digital Image and Video Processing and Compression **(D*)** or Digital Video Processing **(D*)**	3	Y ☐ N ☒
EEE 507	Multidimensional Signal Processing	3	Y ☐ N ☒
CSE 408/598	Multimedia Information Systems	3	Y ☐ N ☒
CSE 515	Multimedia Web Databases	3	Y ☐ N ☒
EEE 509	DSP Algorithms and Software	3	Y ☐ N ☒
EEE 606	Adaptive Signal Processing	3	Y ☐ N ☒
EEE 505	Time-Frequency Signal Processing	3	Y ☐ N ☒
EEE 555	Modeling and Performance Analysis	3	Y ☐ N ☒

*6. **Systems Optimization***

Course prefix & number	**Course title**	**Credit hours**	**New course?**
CSE 450/598	Design and Analysis of Algorithms **(M*)**	3	Y ☐ N ☒
CSE550	Combinatorial algorithms & intractability **(M*)**	3	Y ☐ N ☒
IEE 620	Optimization I (Discrete) **(D*)**	3	Y ☐ N ☒
APM 523	Optimization (Continuous) **(D*)**	3	Y ☐ N ☒
APM 506	Computational methods	3	Y ☐ N ☒
CSE 552	Randomized and Approximation Algorithms	3	Y ☐ N ☒
CSE 555	Theory of Computation	3	Y ☐ N ☒
IEE572 or IEE670	Design of Engineering Experiments or Mathematical Statistics	3	Y ☐ N ☒
IEE533	Scheduling	3	Y ☐ N ☒

IEE574	Applied Deterministic Operations Research Methods	3	Y ☐ N ☒
IEE575	Applied Stochastic Operations Research Methods	3	Y ☐ N ☒

Sample list of elective courses: (post Bachelors)

Course prefix & number	Course title	Credit hours	New course?
CSE 434/598	Computer Networks **(M*)**	3	Y ☐ N ☒
CSE 591	Introduction to Hybrid Systems **(D*)**	3	Y ☐ N ☒
CSE 520	Computer Architecture II **(D*)**	3	Y ☐ N ☒
EEE 525	VLSI design **(D*)**	3	Y ☐ N ☒
CSE 591	Digital Logic Synthesis and Verification Algorithms	3	Y ☐ N ☒
CSE 591	Introduction to Hybrid Systems **(D*)**	3	Y ☐ N ☒
CSE 430/598	Operating Systems	3	Y ☐ N ☒
EEE 598	Digital Signal Processing	3	Y ☐ N ☒
CSE 550	Combinatorial Algorithms and Intractability **(M*)**	3	Y ☐ N ☒
CSE 555	Theory of Computation	3	Y ☐ N ☒
CSE 522	Real Time Embedded Systems **(D*)**	3	Y ☐ N☒
IEE 574	Applied Deterministic Operations Research Methods	3	Y ☐ N ☒

iv. **400-Level Courses.** No more than 6 hours of 400-level coursework can be included on graduate student program of study.

1. Are 400-level ASU courses allowed on student program of study for this degree? ☒ Yes ☐ No

2. If yes, how many credit hours? 6

v. **Additional Requirements (if applicable).** Provide a brief description of any additional requirements (e.g. internships, clinicals, field study, etc.**)** **NONE**

vi. ***Total cr hrs required for research and/or other elective courses per student's research area (if applicable***):

At most **6 credit hours** of "Readings and Conference" (CEN 790)

At least **12 and at most 18 credit hours** of Research (CEN 792)

vii. **Culminating experience** for the proposed program (please check all that apply and provide requested information): **12 credit hours**

	Required?	Course prefix and number	Credit hours
Dissertation **(doctoral only)**	☒	CEN 799	12 cr hrs

viii. **If applicable, provide the following information about any concentration(s) associated with this degree program**. Please attach a sample program of study with timeline for each concentration listed below.

I. Concentration name: Electrical Engineering

***Total cr hrs for the courses required for the proposed concentration*: 18**
(Elective courses used to meet the requirements of section 8.B.iii. may also be counted towards this requirement).

At least 12 cr hrs of graduate level courses in EEE, and
At least 6 cr hrs of graduate level courses in CSE

II. Concentration name: Computer Systems

***Total cr hrs for the courses required for the proposed concentration*: 18**
(Elective courses used to meet the requirements of section 8.B.iii. may also be counted towards this requirement).

At least 12 cr hrs of graduate level courses in CSE, and
At least 6 cr hrs of graduate level courses in EEE

ix. **For Doctoral Degrees, indicate the Master's Degree Credit Allowance:** If approved by the student's supervisory committee, does the program allow up to 30 credit hours from a previously awarded master's degree to count towards the degree requirements for this doctoral program?

☒Yes or ☐No

A student with a Masters degree credit allowance is required to fulfill the four core course requirement, research and dissertation credit hour requirements.

x. **Committee:** Required Number of Thesis or Dissertation Committee Members (must be at least 3 including chair or co-chairs): 4

xi. **Foreign Language Exam.**
Foreign Language Examination(s) required? ☐Yes ☒No

If yes, list all foreign languages required:

xii. **Course Prefix(es)** Provide the following information for the proposed graduate program.
a. Will a new course prefix(es) be required for this degree program?
Yes ☒ No ☐
b. If yes:
- Complete the New Prefix Request Form for each new prefix. This form can be located on the Office of the Executive Vice President and Provost of the University Curriculum Development website at <http://provost.asu.edu/curriculum>.

xiii. **New Courses Required for Proposed Degree Program.** Provide course prefix, number, title, and credit hours and description for any new courses required for this degree program.

Course prefix & number	**Course title**	**Credit hours**	**New course?**
CEN501	Computer Systems I: Circuits to Architectures	3	Y ☒ N ☐
CEN502	Computer Systems II: Fundamentals of Algorithms and Optimization Techniques	3	Y ☒ N ☐

CEN790	Reading and Conference (omnibus course)	1-3	Y ☒ N ☐
CEN792	Research(omnibus course)	1-12	Y ☒ N ☐
CEN799	Dissertation(omnibus course)	1-12	Y ☒ N ☐

CEN 501 Computer Systems I: Circuits to Architectures. This course will cover VLSI Basics (Manufacturing, Mosfet, Basics CMOS gates, Sequential logic + memory) and CAD/Tools (physical design, timing, placement, multi-level logic.

CEN 502 Computer Systems II: Fundamentals of Algorithms and Optimization Techniques. This course will cover basics of computer architecture (instruction set arch., pipelining, multithreaded arch, memory hierarchy, I/O systems), Operating Systems (OS layers, processor scheduling, virtual memory, device drivers), Compilers (parsing, instruction scheduling, register optimization), and Networking (network layers, TCP/IP, routing protocols, hardware/software interface).

Academic Unit Approval – PhD in Computer Engineering (Concentration options in 1. Electrical Engineering and 2. Computer Systems)

From: Ann Zell
Sent: Tuesday, October 19, 2010 9:14 AM
To: 'curriculum@asu.edu'
Subject: Proposal for MS MSE PHD Computer Engineering

The attached proposals for have received Ira A. Fulton Schools of Engineering Curriculum Committee support and Dean's approval. We request that the appropriate university-level committee(s) consider these proposals.

- MS Computer Engineering with a concentration in Electrical Engineering and a concentration in Computer Systems
- MSE Computer Engineering with a concentration in Electrical Engineering and a concentration in Computer Systems
- PhD Computer Engineering with a concentration in Electrical Engineering and a concentration in Computer Systems

Please let me know if you need additional information.

Ann Zell
Assistant Dean, Academic Administration & Student Success
Ira A. Fulton Schools of Engineering at Arizona State University
Tempe, AZ 85287-8109
(480) 965-8931 voice
(480) 965-8095 fax