



**PennState**  
College of Engineering

**ELECTRICAL ENGINEERING  
AND COMPUTER SCIENCE**

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**Computer Science  
and Engineering**

**Fall  
2017**

**Graduate Handbook**

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[www.eecs.psu.edu](http://www.eecs.psu.edu)

# INTRODUCTION

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This graduate booklet has been developed to inform graduate students and faculty in the department of computer science and engineering at Penn State of the policies and guidelines applicable to the graduate programs in this department.

The Penn State Graduate Degree Programs Bulletin contains additional information—this booklet is a supplement to the Bulletin. The Graduate Degree Programs Bulletin is to be viewed as the authority that governs degree programs unless a more stringent requirement is imposed by the department.

All suggestions by graduate students or faculty to enhance the value of this booklet should be made to the graduate program officer of the department. Updates to this booklet will be provided as necessary.

This department is committed to providing a welcoming environment to all students and faculty. Please inform the department head immediately of any barriers—real or perceived—that limit the educational opportunities for students and faculty in this department.

## ADMISSION TO THE COMPUTER SCIENCE AND ENGINEERING GRADUATE PROGRAMS

The department of computer science and engineering offers three graduate programs: a one year professional Master of Engineering in computer science and engineering; a Master of Science in computer science and engineering; and a Doctor of Philosophy in computer science and engineering. The admission requirements are identical for each program.

### Admission Requirements for Graduate Programs in Computer Science and Engineering

All applicants must provide a one-page statement of purpose, three letters of recommendation, and scores from the general aptitude test of the Graduate Record Examination (GRE) in addition to supplying other information requested in the on-line application.

It is expected (but not required) that candidates seeking admission have undergraduate degrees in Computer Science, Computer Engineering, or a closely aligned field. In general, an undergraduate grade point average of 3.0 or higher (out of 4.0) in courses in the major is expected of candidates.

Applicants are expected to have strong GRE scores and an undergraduate junior-senior grade-point average comfortably above 3.0 on a 4.0 scale.

All MS & PhD applicants are considered for available fellowships/teaching assistantships, but preference is given to Ph.D. candidates. Support is not provided to M.Engr. students.

About sixty percent of the graduate students in the department now receive financial assistance of some sort. The projected starting salary for half-time assistants is \$20,520.00 for fall and spring

semesters, and it increases to a maximum of \$22,815.00 (based on experience and duties).

Tuition fees, the computer fee, the College of Engineering surcharge, and 80% of health insurance coverage are included with a teaching and/or research assistantship. A half-time assistant is expected to work approximately twenty hours per week and must schedule 9 to 12 credits per semester. Only a few summer assistantships are available to qualified students.

International students whose first language is not English and will be employed as teaching assistants in Computer Science and Engineering ARE REQUIRED to submit an American English Oral Communicative Proficiency Test (AEOCPT). Depending on the score received in the AEOCPT, students may be required to take English as a Second Language (ESL) courses. All international Ph.D. students are required to take the AEOCPT as part of the CSE Ph.D. requirements. A score of 26 or higher on the speaking section of the TOEFL iBT is equivalent to passing the AEOCPT.

**For score reporting for TOEFL and GRE scores, select "Penn State University".**

**English Proficiency**—The language of instruction at Penn State is English. International applicants must take and submit scores for the TOEFL (Test of English as a Foreign Language) or the IELTS (International English Language Testing System), with the exceptions noted below. For admission purposes, the minimum acceptable score for the TOEFL is 550 for the paper-based test or a total score of 80 with a 19 on the speaking section for the internet-based test. The minimum composite score for the IELTS is 6.5.

International applicants are exempt from the TOEFL/IELTS requirement who have received a baccalaureate or a master's degree from a college/university/institution in any of the following: Australia, Belize, British Caribbean and British West Indies, Canada (except Quebec), England, Guyana, Republic of Ireland, Liberia, New Zealand, Northern Ireland, Scotland, the United States and Wales. Information about the TOEFL can be obtained by writing to the Educational Testing Service, Box 6155, Princeton, NJ 08541-6155 or visiting their website at [www.toefl.org](http://www.toefl.org). Local administration at University Park campus of the TOEFL is handled by the IECF. Information about the IELTS can be obtained by contacting IELTS International, 100 East Corson Street, Suite 200, Pasadena, CA 91103 or visiting its website at [www.ielts.org](http://www.ielts.org).

### Background Courses

All MS & PhD students are expected to have completed appropriate courses in computer architecture and machine organization, data structures and analysis of algorithms, programming languages, operating systems, and logical design/switching theory or theory of automata. MS students who do not meet background requirements will be required to take appropriate 400-level courses to prepare them for 500-level courses. At most, three credits of background course work can be used to satisfy graduate degree requirements.

### Applications and Financial Assistance

Applications for admission for the MS & PhD programs in computer science and engineering will be accepted year-round. Applications for the fall semester should be submitted by December 15 and for the spring semester by August 31. Most students begin their studies in the fall semester. Applicants holding only a BS degree may indicate on their forms that they intend to seek a Ph.D. degree; it is not necessary to have a master's degree first. Applicants applying to the

master's program may later switch to the Ph.D. program. Preference for financial support is given to those applying for the Ph.D. program. Furthermore, students applying for and gaining admittance to the Ph.D. program will not be permitted to switch to the master's program at a later date, except under extenuating circumstances. **M.Engr. applications are only accepted for fall admission.**

**Graduate Application Submission** (all programs):

**Electronic Application** – *This format is the ONLY way to apply.* Applying electronically (online) reduces the processing time and receipt of your application is assured. You can find the electronic application site at [www.gradsch.psu.edu/prospective/apply.html](http://www.gradsch.psu.edu/prospective/apply.html)

Note – make sure that your electronic application is correct and complete. You **will not** be able to change your application once it is submitted.

All application fees must be submitted to the following address by check or money order or by using a credit card through the Graduate School Admissions portal:

Graduate Enrollment Services  
The Pennsylvania State University  
114 Kern Building  
University Park, PA 16802-3391

All application materials, including transcripts, must be uploaded to the electronic application. Your electronic application must be submitted by the deadline, however, recommendation letters may be sent one or two weeks after the deadline.

**You will be notified of your admission decision via email. DO NOT contact the department regarding your admission status.**

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## PROGRAM DESCRIPTIONS/DEGREE REQUIREMENTS

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### *Master of Science in Computer Science and Engineering – 30 credits*

Requirements:

- Background courses (see listing below).
- 15 credits from courses numbered CSE 500-589 or 597\* (9 credits of breadth courses - see listing below). \*Note – 597 courses fall 2013 and after count. 598 courses count prior to fall 2013.
- 9 additional credits of 400 level and above or related areas (excluding – Independent Studies and ENGR 588).
- CSE 590 Colloquium – (1-2 cr.).
- **Effective fall 2009, Scholarship and Research Integrity (SARI) training must be completed during first year of enrollment.**
- Thesis – Students must complete 6 cr. of CSE 600 level and defend their thesis.

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**Background courses**—students must demonstrate knowledge in:

CMPSC 473, Operating Systems Design and Construction,  
 CMPEN 431, Introduction to Computer Architecture,  
 CMPSC 461, Programming Language Concepts,  
 CMPSC 465, Data Structures and Algorithms, and  
 CMPEN 471, Logical Design of Digital Systems or CMPSC 464, Introduction to the Theory of Computation.

**Only 3 credits of the above background courses can be used to satisfy graduate degree requirements.**

**15 credits (9 credits of breadth courses)**, with at least one course from three of the following five breadth groups:

**Group A—Architecture and Communication Systems**

- CSE 513 (Distributed Systems)
- CSE 514 (Computer Networks)
- CSE 515 (Reliable Data Communication)
- CSE 516 (Mobile Networking)
- CSE 517 (Performance Evaluation)
- CSE 530 (Fundamentals of Computer Arch.)
- CSE 554 (Error Correcting Codes for Computers and Communication)

**Group B—Systems**

- CSE 511 (Operating System Design)
- CSE 520 (Science of Computer Programming)
- CSE 521 (Compiler Construction)
- CSE 522 (Semantics of Prog. Languages)
- CSE 541 (Database Systems I)
- CSE 543 (Computer Security)

**Group C—Theory**

- CSE 550 (Numerical Linear Algebra)
- CSE 565 (Algorithm Design and Analysis)
- CSE 588 (Complexity in Computer Algebra)

**Group D—Application**

- CSE 557 (Concurrent Matrix Computation)
- CSE 583 (Pattern Recognition)
- CSE 585 (Digital Image Processing II)
- CSE 586 (Topics in Computer Vision)

**Group E—Hardware Systems Design**

- CSE 572 (Microprocessors and Sys. Design)
- CSE 575 (Architecture of Arithmetic Processors)
- CSE 577 (VLSI Systems Design)
- CSE 578 (VLSI Computer-Aided Design Tools)

## Scholarship and Research Integrity (SARI) Training

The SARI program has two parts:

1. During the first year of enrollment, graduate students will be required to complete an online Responsible Conduct of Research (RCR) training program provided by the Collaborative Institutional Training Initiative (CITI). The Office for Research Protections (ORP) will provide the conduit to this training via the SARI Resource Portal on the ORP website ([www.research.psu.edu/orp/sari](http://www.research.psu.edu/orp/sari)). Students are required to complete the "Responsible Conduct of Research (RCR) Course for Engineers." After completing the exam, print and submit the completion form to the department's graduate staff assistant.
2. Graduate students will also be required to engage in an additional 5 hours of discussion-based RCR education prior to degree completion. These discussions will encompass both universal and discipline-specific material.

**Thesis** – See page 18 for more information.

NOTE: There is a Master of Science in Computer Science and Engineering Degree Checklist in Appendix II.

## **Master of Engineering in Computer Science and Engineering – 30 credits**

Admission is in the Fall semester.

Requirements:

- Fall Semester: CmpSc 465 AND EITHER (CmpSc 443 and CmpSc 431W) OR (CmpEn 431 and CmpEn 472) AND one CSE graduate level course numbered CSE 500-589 or 597
- Spring Semester: 12 credits of CSE graduate level courses number CSE 500-589 or 597.
- Summer Semester: CSE 820 (3) and CSE 594 (3) – both online. CSE 594 includes the completion of a paper as a final project.
- **Scholarship and Research Integrity (SARI) training must be completed during first year enrollment.**

2. Graduate students will also be required to engage in an additional 5 hours of discussion-based RCR education prior to degree completion. These discussions will encompass both universal and discipline-specific material.

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NOTE: There is a Master of Engineering in Computer Science and Engineering Degree Checklist in Appendix II.

### **Scholarship and Research Integrity (SARI) Training**

The SARI program has two parts:

1. During the **first year of enrollment**, graduate students will be required to complete an online Responsible Conduct of Research (RCR) training program provided by the Collaborative Institutional Training Initiative (CITI). The Office for Research Protections (ORP) will provide the conduit to this training via the SARI Resource Portal on the ORP website ([www.research.psu.edu/orp/sari](http://www.research.psu.edu/orp/sari)). Students are required to complete the "Responsible Conduct of Research (RCR) Course for Engineers." After completing the exam, print and submit to the department's graduate staff assistant.

### *Doctor of Philosophy in Computer Science and Engineering*

**PLEASE NOTE:** Students applying for and gaining admittance to the Ph.D. program will not be permitted to switch to the master's program at a later date, except under extenuating circumstances.

1. **Requirements prior to Fall 2017:** Students who are entering the Ph.D. program with a Master of Science degree may count up to 30 credits to satisfy item 2) below.
2. **Requirements prior to Fall 2017: Graduate Courses** – students must accumulate a minimum of 48 credits of non-thesis graduate level courses, with at least 27 credits of courses with numbers CSE 500-589 or CSE 597\*, and 21 additional credits of 400 level and above courses. This must include 3 credits of CSE 590 [colloquium; only 3 credits of CSE 590 can be counted towards the 48 minimum credits]. A maximum of 3 credits of X96 also can be counted. \*Note – 597 courses fall 2013 and after count. 598 courses count prior to fall 2013.
3. **New Ph.D. Course Requirements Effective Fall 2017:** students who **do not have** an MS degree in Computer Science or Computer Engineering must take a minimum of **33** credits including 6 credits of CSE 565, CSE 511 or CSE 530; 15 credits of CSE courses, excluding CSE 596 and 598; 9 credits of 400-, 500-, or 800-level courses in CSE/EE/MATH/STAT, or 500- or 800-level IST courses (which may include up to 3 credits of CSE 596); 2 credits of CSE 590 (Colloquium), and 1 credit of CSE 591. Students **who have** an MS degree in Computer Science or Computer Engineering must take a minimum of **21** credits including 6 credits of CSE 565, CSE 511 or CSE 530, 9 credits of CSE courses, excluding CSE 596 and 598; 3 credits of 400-, 500- or 800-level courses in CSE/EE/MATH/STAT, or 500- or

800-level IST courses (which may include up to 3 credits of CSE 596); 2 credits of CSE 590 Colloquium and 1 credit of CSE 591.

4. **Effective Fall 2009, Scholarship and Research Integrity (SARI) training must be completed during first year enrollment.**

#### **Scholarship and Research Integrity (SARI) Training**

The SARI program has two parts:

1. During the **first year of enrollment**, graduate students will be required to complete an online Responsible Conduct of (RCR) training program provided by the Collaborative Institutional Training Initiative (CITI). The Office for Research Protections (ORP) will provide the conduit to this training via the SARI Resource Portal on the ORP website ([www.research.psu.edu/orp/sari](http://www.research.psu.edu/orp/sari)). Students are required to complete the "Responsible Conduct of Research (RCR) Course for Engineers." After completing the exam, print and submit to the department's graduate staff assistant.
2. Graduate students will also be required to engage in an additional 5 hours of discussion-based RCR education prior to degree completion. These discussions will encompass both universal and discipline-specific material.



Other requirements include:

### Course Breadth Requirement

In addition to the candidacy exam requirement, all CSE Ph.D. graduate students will need to satisfy the following course requirements **before graduation**.

1. Pass a graduate breadth course from at least three of the eleven candidacy subject areas (see page 20 for a list of areas **and courses**).
2. At least two of these three courses must not overlap with the areas of your candidacy exam subject areas.
3. At least one of the two subject areas listed below must be covered either by passing the candidacy examination in that area or by completing the graduate breadth course specified.
  - a. Data Structures and Algorithms
  - b. Programming Languages
4. At least one of the two subject areas listed below must be covered either by passing the candidacy examination in that area or by completing the graduate breadth course specified.
  - a. Operating System
  - b. Computer Architecture
4. **Ph.D. candidacy examination** – candidacy examination consisting of:
  - a) **CSE 591** Research Experience in Computer Science and Engineering [1 credit] – must be completed within the first two regular semesters after entering the Ph.D. program (a grade of B or higher must be achieved); **can only be taken once**, and
  - b) **Written examination** – Must be completed within the first three regular semesters, which is offered at the beginning of each fall and spring semester. The examination tests the student's background preparation and problem-solving ability.

In the Candidacy Exams, students are required to attempt and pass examinations in three out of the eleven subject areas listed on page 20. Each subject area examination will have a duration of two hours. **By the second semester, students must have attempted at least three areas (with a demonstrated performance in all three)**. A student is limited to three chances to pass the candidacy, and will have to take the exam in the first semester of residence in order to avail themselves of the three-chance rule. The students will need to register with the graduate staff assistant for the examination and identify the three subject areas no later than two weeks before the date of the examination. **Students must pass three subject area exams no later than the third regular semester after entering the Ph.D. program.**

Examinations taken as an M.S. or as an M.Eng. student will count towards the maximum limit of three attempts. When a master's student starts taking candidacy exams, they must complete within three semesters (this is the same as Ph.D.)

The level of the examination is that of undergraduate courses in the designated subject areas, although the questions are not necessarily restricted to topics covered in any specific course. The graduate program officer of the department will assign coordinators for each examination. Special conditions set for an examination (such as open book) will be promulgated by the area coordinator four weeks prior to the examination.

5. **Comprehensive examination** – students must pass the Ph.D. comprehensive examination, and the English competency and communication requirements. Students must be registered in order to take the comprehensive exam. Students must be continuously registered each fall and spring

semesters after the comprehensive exam.

**Please see the graduate staff assistant for more information about this process.**

6. **Dissertation** – students must complete and defend a Ph.D. dissertation. Students must be registered in order to defend a Ph.D. dissertation. **Please see the graduate staff assistant for more information about this process.**
  
7. **English Competency Assessment** – all incoming Ph.D. students will have their English competencies assessed. All students will have their writing and presentational speaking competencies assessed via a departmental assessment. International students will in addition have their writing, oral, and presentational speaking competencies assessed via the AEOCPT. These assessments will take place in each fall and spring semester. Based on the results of these assessments, students with documented deficiencies will be required to pursue one or several opportunities that are identified for appropriate skill enhancement. **The AEOCPT and departmental assessment must be successfully completed before scheduling the comprehensive examination.** The department will pay for the AEOCPT exam fee for exams taken during the normal schedule. You must notify the graduate staff assistant immediately if you are not able to attend any of the dates provided. Should you schedule your exam on a date that is not a normally scheduled date, **you may be responsible for the additional fees.**

NOTE: There is a Doctor of Philosophy in Computer Science and Engineering Degree Checklist in Appendix II.

Please refer to the Graduate Bulletin for further information about graduate policies and procedures:  
<http://bulletins.psu.edu/bulletins/whitebook/in dex.cfm>

## OTHER PROGRAMS/REQUIREMENTS

**Exceptions**—In very rare situations, petitions will be considered for acceptance of certain CSE 598\* course offerings (or a related course from another department) as meeting the requirements for master's and doctoral degrees. These petitions can only be submitted with **prior approval of and strong support from your advisor**; they will only be entertained under extenuating circumstances such as the late cancellation of a required course. Petitions should be submitted to the Graduate Program Officer. \*Exceptions for 598 courses fall 2013 and after – for 597 courses prior to fall 2013.

**Optional Minor**—A minor consists of at least 6 graduate credits in an approved area. The department in which the student wants to minor must approve the course selection for the minor. Students planning to take an optional minor must petition, in writing, to the Graduate Program Officer before taking courses in the intended minor. The student's academic advisor must sign this petition. The Graduate School gives final approval. The Computer Science and Engineering Department does not offer a minor in Computer Science and Engineering.

### Post Baccalaureate Credit Certificate Program in Computer and Network Security

The goal of this certificate program is to prepare security analysts and researchers to develop and apply advanced security needs of enterprise and personal environments.

#### *Admission Requirements:*

The successful applicant will possess a baccalaureate degree in computer science, computer engineering, or a closely aligned field from Penn State or another accredited institution

and is generally expected to have a minimum GPA of 3.0. International students must satisfy the Graduate School's English language requirement. Professional experience will be taken into consideration for admission. Exceptions to the minimum 3.0 grade-point average may be made for students with special backgrounds, abilities, and interests.

GRE scores are not required for non-degree graduate students. Individuals who wish to apply to the graduate program in computer science and engineering must submit an application for admission to the graduate program, along with all of the required supporting documentation, including GRE scores.

#### *Required Course Work:*

12 credits: CSE 543 AND three of the following courses: CMPSC 443, CSE 544, CSE 545, CSE 546.

Students must complete the required courses with an average GPA of 3.0 and a grade of no less than B- in each course.

#### *Contact:*

Dr. Patrick McDaniel  
360-A Info. Sciences & Technology Building  
Phone: 814-863-3599  
FAX: 814-865-3176  
E-mail: mcdaniel@cse.psu.edu

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### Operations Research Dual-Title Degree Program

tailor a plan of graduate study to meet career objectives in both of the chosen fields.

Graduates students within computer science and engineering can elect to participate in the Operations Research Dual-Title Degree Program. Operations Research is the use of scientific methodology in the formulation, analysis, and solution of problems of decision making. The term Operations Research originated in World War II to describe studies of military operations involving man-machine systems. Since its origin, operations researchers have addressed a wide variety of problems, including production and inventory control, transportation and distribution system design, capital investment marketing strategies, health maintenance, pollution control, personnel staffing, military deployment, resource management and other regional planning problems, just to name a few. The applications of operations research are numerous, and more importantly, new applications are continually arising. The strength and versatility of operations research lie in its ability to model the behavior of complex systems in quantitative mathematical terms, as well as its prescriptive power through analysis and synthesis.

Operations Research is interdisciplinary by nature and draws on the techniques from many fields, including the mathematical sciences, engineering, economics, and the physical sciences. The unique structure of the OR program at Penn State enables students from rather diverse backgrounds to attain and be identified with the tools, techniques, and methodology of Operations Research and at the same time maintain a close association with their field of major interest. The opportunity to study and work with others from such diverse backgrounds provides an enriching experience not usually available in graduate work. By a judicious selection of courses, a student can

## REGISTRATION REQUIREMENTS

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Registration as a full-time student is required for each student receiving assistantship support. Full-time status is defined as:

|                      | Fall/Spring           | Summer      |
|----------------------|-----------------------|-------------|
| ¼-time assistantship | 9-14 credits/semester | 5-7 credits |
| ½-time assistantship | 9-12                  | 4-6         |
| ¾-time assistantship | 6-8                   | 3-5         |

Students holding fellowships, traineeships, or other awards are required to carry 9 or more credits each semester, and 5 or more during the summer session. All international students must register for at least 9 credits during the fall and spring semesters.

The College of Engineering requires that every new engineering teaching assistant complete ENGR 588, the Graduate Teaching Seminar, during their first semester as a teaching assistant where they are responsible for teaching in the classroom (actual classes, recitations, or labs).

### Time Limits and Other Constraints

An M.S. degree must be completed within eight years of admission to degree status. An M.Engr. degree must be completed in one year. A doctoral student is required to complete the program, including acceptance of the doctoral thesis, within eight years from the date of acceptance as a candidate (passing Ph.D. Candidacy Exam).

Prior scheduling of comprehensive and final oral exams for Ph.D. candidates is required. Both the comprehensive and final oral exam must be scheduled at least four weeks in advance. The exams may be canceled if documents (specifically, the thesis proposal and thesis,

respectively) are not delivered to committee members at least two weeks prior to exams. Students must be registered in order to take the comprehensive exam. Please see the graduate staff assistant for more information about this process.

Final oral exams and dissertation submissions must meet published deadlines each semester or summer for graduation at the end of that semester or summer.

Students must be registered in order to defend a Ph.D. dissertation. Please see the graduate staff assistant for more information about this process.

### Residency Requirement

Over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program, the candidate must spend at least two semesters (which may include the semester in which the candidacy examination is taken) as a registered full-time student engaged in academic work at the University Park Campus.

After passing the comprehensive exam and meeting the two-semester full-time residency requirement, the Ph.D. student **must maintain** continuous registration for each fall and spring semester (beginning with the first semester after both of the above requirements are met) until the Ph.D. thesis is accepted and approved by the doctoral committee. Note that if a student is in residence during summers, he/she must also register for summer sessions. Post comprehensive students can maintain registration by registering for credits in the usual way or by registering for noncredit 601 or 611, depending on whether they are devoting full-time or part-time to their thesis preparation. *Students who do*

*not register are subject to retroactive tuition assessments.*

To be eligible for candidacies, comprehensives, and final orals, a minimum grade point average of 3.0 is mandatory. Also, a minimum grade point average of 3.0 is mandatory to receive a graduate degree from Penn State. **Courses below the 400 level and courses in which a grade less than C is earned do not count towards graduation.**

Students who have been appointed on a graduate assistantship or fellowship for fall and spring semesters are eligible to apply for the Summer Tuition Assistance Program (STAP). Please see the graduate staff assistant for more information about this program.

Please refer to the Graduate Bulletin for further information about graduate policies and procedures:  
<http://bulletins.psu.edu/bulletins/whitebook/index.cfm>

## NORMAL ACADEMIC PROGRESS

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**M.S. & Ph.D.:** Students pursuing M.S. or Ph.D. graduate degrees in the Department of Computer Science and Engineering are expected to complete the minimum credit requirement each semester and to maintain an acceptable academic grade point average. Acceptable is understood to mean a minimum 3.00 GPA. Students who fall below these standards will be considered on academic probation. If a student remains below this standard for two consecutive semesters, he/she may be terminated. For Ph.D. students, normal academic progress also entails the undertaking of the candidacy exam, **with a strongly demonstrated effort in each Exam each time it is attempted.** See the section on Ph.D. Candidacy Examinations for the complete guidelines. **Please note that the normal academic progress requirement plays a strong role in determining continuing financial support.** Graduate studies will be terminated if a PhD student fails the comprehensive examination or a master's or PhD student fails their thesis/dissertation defense, unless the master's doctoral committee votes to allow for another examination. A PhD student will also be terminated from their program if they fail to pass 3 candidacy examinations in the first 3 semesters, although they may be allowed to complete a master's degree if both their research adviser and the Graduate Program Officer approve.

**M.Engr.:** The M.Engr. is a cohort based program. The program is started in the fall semester and completed in one year in the following summer semester. If a student fails to register for the appropriate courses in any semester or fails to earn at least a C in any course they may be terminated from the program.

## DURATION OF ASSISTANTSHIP SUPPORT

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Those students who initially enter one of our departmental programs with support from a Teaching Assistantship are normally supported for two 15-week semesters provided that they show continued acceptable (as defined above) academic progress, and fulfill the obligations of their Teaching Assistantship. In addition, international students are expected to pass the American English Oral Communicative Proficiency Test (AEOCPT) or complete all required courses remedial English courses. All Ph.D. students must also satisfy the Ph.D. English Proficiency testing.

**The CSE Department will not support M.Engr. students via an assistantship or other financial aid.**



## CSE FACULTY WITH A FINANCIAL APPOINTMENT IN CSE

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M.Engr. students will be advised by the Professor in Charge of the M.Engr. program. M.S. and Ph.D. graduate student will be assigned a graduate advisor upon admission into the graduate program. This advisor will assist the student in planning a preliminary graduate degree program. This key process is to both insure that students have met background requirements and to help prepare a schedule of courses for the first semester of enrollment. This advisor will remain the graduate advisor until the student forms a committee to advise the student on an M.S. thesis, or Ph.D. thesis. It is the responsibility of the student to form a research committee (see RESEARCH COMMITTEES). The student should discuss research opportunities with faculty in the department. After obtaining the agreement of a faculty member to serve as research advisor, the student may choose to have this research advisor serve as their academic advisor as well; **the graduate staff assistant must be notified of this choice.** The student will then form the appropriate research committee. The following is an abbreviated faculty research interest list.

**Faculty Areas of Interest** (email extension is @cse.psu.edu unless otherwise noted)

**Jesse L. Barlow** (CSE), professor. Numerical linear algebra, scientific computing, linear algebra in signal and image processing. (863-1705; barlow@)

**Piotr Berman** (CSE), associate professor. Computational complexity, approximation algorithms, theory of distributed systems, computational molecular biology. (865-1611; berman@)

**Guohong Cao** (CSE), professor. Wireless networks, mobile computing, wireless network security, vehicular ad hoc networks, wireless sensor networks, data access and dissemination. (863-1241; gcao@)

**Kyusun Choi** (CSE), associate professor. Mixed-signal VLSI circuit design, RF ASICs, DSP architecture for RF signal, 4G wireless wrist PDA, embedded microcomputer, in vivo biomedical instrumentation. (863-1268; kyusun@)

**Robert Collins** (CSE), associate professor. Computer vision, with current emphasis on video scene understanding, automated surveillance, human activity modeling, and real-time tracking. (863-1944; rcollins@)

**Chita R. Das** (CSE), department head, distinguished professor. Computer architecture, parallel and distributed computing, cluster systems, network-on-chip (NoC) architectures, Internet QoS, mobile computing, performance evaluation, fault-tolerant computing, multimedia systems. (865-0194; das@)

**Martin Fürer** (CSE), professor. Efficient discrete and algebraic algorithms, approximation algorithms, computational complexity, the graph isomorphism problem. (863-1857; fürer@)

**Swaroop Ghosh** (CSE/EE), assistant professor. Circuits, micro-architecture and hardware security. (szg212@psu.edu)

**Sean Hallgren** (CSE), professor. Theoretical computer science, quantum computing. (863-1265; hallgren@)

**John J. Hannan** (CSE), associate department head and associate professor. Programming language semantics and implementation, program analysis and verification, logic and computation, type theory, functional programming. (863-0702; hannan@)

**Ting He** (CSE), associate professor. Network science, network security, statistical inference, performance analysis and optimization. (865-1265; T.He@)

**Trent Jaeger** (CSE), professor. Computer security, operating systems, security policies, source code analysis. (865-1042; tjaeger@)

**Mahmut Kandemir** (CSE), professor. Optimizing compilers, chip multiprocessing, programming languages, high performance I/O, parallel file systems. (863-4888; kandemir@)

**George Kesidis** (CSE/EE), professor. Network security, anomaly detection, design and performance evaluation of communication/computer networking mechanisms, incentive engineering, optimization, stochastic processes and probability, applied statistics and machine learning. (865-9190; kesidis@)

**Daniel Kifer** (CSE), associate professor. Private data analysis, text models, data mining, machine learning. (863-1187; dkifer@)

**Thomas F. La Porta** (CSE/EE), EECS director, Evan Pugh Professor, distinguished professor. Mobility management, mobile data systems including networks, protocols, and applications, signaling and control for telecommunication networks, security for wireless networks. (865-6725; tlp@)

**Wang-Chien Lee** (CSE), associate professor. Database systems, data mining, social computing, information retrieval, pervasive and mobile computing, location-based services, peer-to-peer networks, wireless sensor networks, Internet technologies. (865-1053; wlee@)

**Yanxi Liu** (CSE/EE), professor. Computational regularity, group theory and applications, machine learning (particularly discriminative subspace learning from multimedia data), computer-aided diagnosis, computer vision and computer graphics (textures, urban scenes, dance, taiji), biomedical image analysis/indexing/retrieval, robotics. (865-7495; yanxi@)

**Kamesh Madduri** (CSE/Huck Institute), assistant professor. Combinatorial scientific computing, scalable scientific data analysis and management, parallel graph algorithms, computational genomics. (865-0883; madduri@)

**Patrick D. McDaniel** (CSE), professor. Systems and network security, security policy, networking, distributed systems, public policy, network management, applied cryptography, privacy. (863-3599; mcdaniel@)

**Paul Medvedev** (CSE/BMB), assistant professor. Computational genomics, cancer genomics, theoretical computer science, algorithm design and analysis, graph theory. (865-0193; pashadag@)

**Vijaykrishnan Narayanan** (CSE/EE), distinguished professor. Reconfigurable and embedded systems, brain-inspired architectures, ultra-low power devices and systems, computer architecture. (863-0392; vijay@)

**Rebecca Passonneau** (CSE), professor. Computational semantic and pragmatics, natural language processing (NLP), dialog systems, data mining. (865-9233, passonneau@)

**Sofya Raskhodnikova** (CSE), professor. Sublinear time algorithms, randomized and approximation algorithms, computational complexity, private data analysis. (863-0608; sofya@)

**John Sampson** (CSE), assistant professor.  
Computer architecture, mobile/low-power  
computing, application/domain-specific  
architectures. (863-7323; sampson@)

**Anand Sivasubramaniam** (CSE), professor.  
Operating systems, computer architecture,  
databases, mobile computing, performance  
evaluation. (865-1406; anand@)

**Adam Smith** (CSE), professor. Cryptography,  
database privacy, information theory, quantum  
computing. (863-0076; asmith@)

**Gang Tan** (CSE), associate professor. Security,  
programming languages, formal methods,  
software engineering. (865-7364; gtan@)

**Bhuvan Uргаonkar** (CSE), associate professor.  
Performance evaluation, distributed systems,  
operating systems/virtual machines, storage  
systems, power management, cloud computing.  
(865-9506; bhuvan@)

**Danfeng Zhang** (CSE), assistant professor.  
Computer security, programming languages.  
(863-7323; dbz5017@psu.edu)

**Sencun Zhu** (CSE/IST), associate professor.  
Network and systems security, software  
protection, wireless security, privacy, children  
online safety. (865-0995; szhu@)

# RESEARCH COMMITTEES

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## M.S. Degree Committee

By the end of the first semester of study, the student should formulate a plan of research and identify members of the Master's Degree Committee. The student should present a written proposal in the form of a letter to the Graduate Program Officer (via the graduate staff assistant) of the department. This letter should include the names of faculty willing to serve on the committee; should clearly identify the chairperson of the committee; and the supervisor of the research, if other than the chairperson. The research proposal should consist of the following:

- i) Proposed title
- ii) Summary of the investigation proposed
- iii) A timetable for completion of the work

The committee chairperson or co-chairperson must be a faculty member whose name appears on the list of faculty starting on page 15. A second member of the committee must be a member of the graduate faculty of the CSE department. A committee must consist of at least two members. One of the two graduate faculty must be tenure-track faculty whose home department is CSE. There may be additional members, including a co-chairperson, who are members of the graduate faculty at large. It is understood that the proposal is preliminary and modifications to the research plan will occur. If significant deviations occur, an addendum should be filed with the Graduate Program Officer (via the graduate staff assistant).

### *M.S. Thesis*

The work need not necessarily be an in-depth investigation to extend the state of the art in some specialty area. However, mere application of some existing theory or technology is generally not sufficient. **A public thesis defense is required.**

## M.Engr.

M.Engr. students are advised by the Professor-in-Charge of the M.Engr. program. Since the M.Engr. is a professional degree and not a research degree, no committee is formed nor is a thesis written. A paper will be completed as a final project in the course CSE 594.

## Ph.D. Committee

During the semester in which a student is admitted to candidacy, he/she is expected to form the doctoral committee, which will consist of at least three members of the graduate faculty of the CSE department and one graduate faculty member from outside the department. Two of the four graduate faculty must be tenure-track faculty whose home department is CSE. The chairperson or a co-chairperson must be a faculty member whose name appears on the list of faculty starting on page 15. Either the chairperson or co-chairperson will be the primary research consultant.

**Please refer to the Graduate Bulletin for further information about graduate policies and procedures:**

**<http://bulletins.psu.edu/bulletins/whitebook/index.cfm>**

The student requests the appointment of their committee by obtaining the signature of each graduate faculty member on the Committee Appointment Signature form (available from the graduate staff assistant) and returning it to the graduate staff assistant for submission to the Graduate Enrollment Services Offices, and submitting in letter form to the graduate program officer (via the graduate staff assistant), the following:

- i) Proposed title of dissertation
- ii) An appropriately worded summary of the investigation for the dissertation
- iii) The name of the proposed doctoral committee members and the role each member will play

It is understood that the proposal is preliminary and that modifications will occur. If significant modifications do occur, the graduate program officer should be notified (via the graduate staff assistant). **A public thesis defense is required.**

# PH.D. CANDIDACY EXAMINATIONS

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All students in the Ph.D. program are required to take CSE 591 (1 credit), Research Experience in Computer Science and Engineering (course may only be taken once and must be completed within the first two regular semesters after entering the Ph.D. program and (a grade of B or higher must be achieved), and to pass a written Candidacy Examination within the first three regular semesters, which is offered at the beginning of each fall and spring semester. The examination tests the student's background preparation and problem-solving ability.

In the Candidacy Exams, students are required to attempt and pass examinations in three out of the eleven subject areas listed below. Each subject area examination will have a duration of two hours. **By the second semester, students must have attempted at least three areas (with a demonstrated performance in all three).** A student is limited to three chances to pass the candidacy, and will have to take the exam in the first semester of residence in order to avail themselves of the three-chance rule. The students will need to register with the graduate staff assistant for the examination and identify the three subject areas no later than two weeks before the date of the examination. **Students must pass three subject area exams no later than the third regular semester after entering the Ph.D. program.** Examinations taken as an M.S. or as an M.Eng. student will count towards the maximum limit of three attempts.

The level of the examination is that of undergraduate courses in the designated subject areas, although the questions are not necessarily restricted to topics covered in any specific course. The graduate program officer of the department will assign coordinators for each examination. Special conditions set for an examination (such as open book) will be

promulgated by the area coordinator four weeks prior to the examination.

## Course Breadth Requirement

In addition to the candidacy exam requirement, all CSE Ph.D. graduate students will need to satisfy the following course requirements **before graduation**.

1. Pass a graduate breadth course from at least three of the eleven subject areas.
2. At least two of these three courses must not overlap with the areas of the passed candidacy exam subject areas.
3. At least one of the two subject areas listed below must be covered either by passing the candidacy examination in that area or by completing the graduate breadth course specified.
  - a. Data Structures and Algorithms
  - b. Programming Languages
4. At least one of the two subject areas listed below must be covered either by passing the candidacy examination in that area or by completing the graduate breadth course specified.
  - a. Operating System
  - b. Computer Architecture

## SUBJECT AREA 1: ALGORITHMS AND DATA STRUCTURES IN BIOINFORMATICS:

Exam covers the following topics:

- Sequence alignment: Edit distance, global sequence alignment, local sequence alignment, gap penalties, multiple sequence alignment
- Pattern Matching: Suffix trees and suffix arrays and their uses
- Phylogeny: distance-based phylogeny (including UPGMA and Neighbor Joining algorithms), sequence-based phylogeny (including Fitch's and Sankoff's algorithms)
- Hidden Markov models: Viterbi algorithm, Forward algorithm, Backward –Forward algorithm, Parameter estimation (including Viterbi training and BaumWelsch)

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPSC 497F/BMB 497F: Introduction to Bioinformatics

### Suggested references:

1. Durbin, Eddy, Krogh, Mitchison. *Biological Sequence Analysis*, Cambridge University Press, 1998.
2. Gusfield. *Algorithms on Strings, Trees, and Sequences*, Cambridge University Press, 1997.
3. Gusfield. *Algorithms on Strings, Trees, and Sequences*, Cambridge University Press, 1997.

### Graduate Breadth Courses:

CSE 566: Algorithms and Data Structures in Bioinformatics

## SUBJECT AREA 2: COMPUTER ARCHITECTURE AND ORGANIZATION

Exam covers the following topics:

- Arithmetic Logic Unit: Analysis of arithmetic operations and design of arithmetic units (adders, multipliers, dividers, etc.); floating point representations and operations.
- CPU Design: hardware description languages; datapath design and busing structures; pipelined datapath; data and control hazards; control unit design.
- Processor Design: instruction sets; addressing modes; performance metrics; architectural support for subroutine calls and interrupt handling.
- Memory Systems: memory hierarchy and memory types; cache memory designs; interleaved memory; architectural support for virtual memories.
- I/O Systems: types and characteristics of I/O devices; I/O device interfacing (I/O buses, interrupts, DMA, etc.)
- Concurrency: Different approaches to concurrency, i.e., pipelining, parallelism, and multiprocessing, and their architectural characteristics.

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPEN 331: Computer Organization and Design

CMPEN 431: Introduction to Computer Architecture

### Suggested references:

1. Patterson and Hennessy. *Computer Organization and Design: The Hardware/Software Interface*, 4<sup>th</sup> Edition. Morgan Kaufmann, 2008.
2. Hamacher et. al. *Computer Organization*, 5<sup>th</sup> Edition. McGraw Hill, 2002.

3. Hennessy and Patterson. *Computer Architecture A Quantitative Approach*, 4<sup>th</sup> Edition. Morgan Kaufmann.

**Graduate Breadth Courses:**

CSE 530: Fundamentals of Computer Architecture

**SUBJECT AREA 3: COMPUTER NETWORKS**

Exam covers the following topics:

- Computer Networks and the Internet: Internet, network structure, protocol stack.
- Application Layer: HTTP, FTP, SMTP, DNS, content distribution.
- Transport Layer: UDP, TCP, sliding window, congestion control.
- Network Layer and Routing: Routing principles, IP, IPv6, multicast, mobile IP.
- Link Layer and Local Area Networks: Multiple access control, LAN, Ethernet, wireless links, ATM.

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPEN/EE 362: Communication Networks

**Suggested references:**

1. Kurose, J., K. Ross, *Computer Networks: A Top-Down Approach Featuring the Internet*, 5<sup>th</sup> Edition, 2010.
2. Tanenbaum, A. *Computer Networks*, 4<sup>th</sup> Edition. Prentice Hall, 2005.

**Graduate Breadth Courses:**

CSE 514: Computer Networks



## SUBJECT AREA 4: COMPUTER VISION AND DIGITAL IMAGE PROCESSING

Exam covers the following topics:

### I. Digital Image Processing

- Digital Image Fundamentals: Image sensors, sampling, quantization, pixel geometry [GW Ch.2; TV Ch.2]; Photometric concepts: color and light, illumination, reflection, sensor response [GW Ch.6; FP Ch.4&6]; Camera geometry: projection models, camera parameters, calibration [FP Ch.2; TV Ch.6].
- Image Enhancement: Histogram analysis and equalization. Linear operators and convolution; noise and smoothing; sharpening operators; computing image gradients; Gaussian derivatives and LoG operator; median filtering. [GW Ch.3; TV Ch.3].
- Frequency-Domain Filtering: Fourier transform; Discrete Fourier Transform (DFT) and FFT; filtering in frequency domain [GW Ch.4].
- Image Compression: Information theory and coding theorems; lossless vs. lossy compression; predictive compression methods; JPEG - still image compression; MPEG - motion video compression [GW Ch.8].
- Binary Morphology: Basic operations: erosion, dilation, thinning, region filling, connected components [GW Ch.9].

### II. Computer Vision

- Feature Extraction: Edge detection; case study: Canny algorithm [TV Ch.4]; Line/curve fitting: least squares, RANSAC and Hough transform [TV ch.5]; Corner detection; case study: Harris algorithm [TV Ch.4]; Region segmentation: split&merge; region growing [GW Ch.10].

- Image Mappings: Forward/inverse geometric warping and interpolation [GW Ch.5.11]; Parametric transformations (translation, rotation, scale, Euclidean, similarity, affine, projective) [course notes].
- Stereopsis: Parallax vs. depth; correspondence problem and patch matching via SSD and NCC; epipolar geometry; Essential vs. Fundamental matrix; image rectification; stereo reconstruction [TV Ch.7; FP ch.11].
- Motion: Motion field vs. optical flow; aperture problem and normal flow; computing optical flow (case study: Lucas-Kanade algorithm); structure from motion; the Factorization algorithm; change detection [TV Ch.8].
- Tracking: Correlation-based approaches (e.g. template matching); mean-shift algorithm (e.g. CAMSHIFT) [course notes].
- Object Recognition: Interpretation trees; invariants; appearance-based (eigenspace) methods [TV Ch.10].

Penn State courses CMPEN 454 and CMPEN 455 are recommended as providing a minimal background in the exam topics. It is also expected that the student has mastered background knowledge in college-level linear algebra and probability theory.

#### Suggested references:

1. [GW] Gonzalez and Woods. *Digital Image Processing*, 3<sup>rd</sup> Edition. Prentice Hall, 2008.
2. [TV] Trucco and Verri. *Introductory Techniques for 3D Computer Vision*. Prentice Hall, 2005.
3. [FP] Forsyth and Ponce. *Computer Vision: A Modern Approach*. Prentice Hall, 2003.

#### Graduate Breadth Courses:

CSE 585: Digital Image Processing II  
CSE 586: Topics in Computer Vision

**SUBJECT AREA 5: DATA STRUCTURES AND ALGORITHMS**

Exam covers the following topics:

- Representation of Basic Data Structures: arrays, stacks, queues, linked lists, trees, graphs, binary search trees, balanced trees, hash tables.
- Algorithmic Design Techniques: divide and conquer, greedy, dynamic programming.
- Sorting and Order Statistics.
- Graph Algorithms: searching, minimum spanning trees, shortest paths (single-source and all-pairs).
- Growth of Functions, Recurrences and Time Analysis.

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPSC 465: Data Structures and Algorithms

**Suggested references:**

1. Cormen, Leiserson, Rivest, and Stein. *Introduction to Algorithms*. 3<sup>rd</sup> edition MIT Press, 2009.
2. Kleinberg, Tardos. *Algorithm Design*, Addison-Wesley, 2005.

**Graduate Breadth Courses:**

CSE 565: Algorithm Design and Analysis

**SUBJECT AREA 6: NUMERICAL ANALYSIS AND SCIENTIFIC COMPUTING**

Exam covers the following topics:

- Rounding Error and Floating Point Arithmetic: Floating point systems, Rounding Errors, Underflows, Overflows, IEEE Floating Point Standard, Accumulated rounding error and its role in algorithm development
- Linear Algebra Background: inner products, vector and matrix norms
- Linear Least Squares Problems: the basics of the problem, Householder and Givens QR decomposition, Gram-Schmidt QR decomposition and its variants, normal equations, conditioning issues
- Nonlinear Equations: solving nonlinear equations in one variable, bisection method, Newton's method, secant method, Newton's method for several variables
- Eigenvalue Problems: Basics of the Eigenvalue problem-symmetric vs. non-symmetric, singular value decomposition (background only, no methods), power method and variants, reductions to condensed form (either Hessenberg or Tridiagonal)
- Polynomial Interpolation: Taylor series background, basic notations of interpolation-existence and uniqueness, Newton divided difference form, Vandermonde matrix, Lagrange basis function, error in polynomial interpolation
- Piecewise Polynomial Interpolation: Piecewise linear and Hermite interpolation, cubic spline interpolation
- Numerical Integration: Interpolatory formulation of numerical integration, Newton-Cotes formulas, Richardson extrapolation and Romberg integration, Gaussian quadrature, adaptive quadrature

- Numerical differentiation and Richardson's extrapolation: Using Taylor series to derive formulas, using Lagrange interpolation to derive formulas, role of Richardson extrapolation

#### Suggested References:

1. David Kincaid and Ward Cheney. *Numerical Analysis, Mathematics of Scientific Computing*. 3<sup>rd</sup> Edition, Brooks/Cole, CA, 2001.
2. U.M. Ascher & C. Grief. *A First Course in Numerical Methods*, SIAM Publications, Philadelphia, 2011.
3. A. Greenbaum & T. Chartier. *Numerical Methods: Design, Analysis, and Computer Implementation of Algorithms*. Princeton, University Press, Princeton, NJ, 2012

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPSC 455: Numerical Analysis I  
CMPSC 456: Numerical Analysis II

#### Graduate Breadth Courses:

CSE 550: Numerical Linear Algebra

## SUBJECT AREA 7: OPERATING SYSTEMS

Exam covers the following topics:

- Process Management: processes, threads, context switching, scheduling, interprocess communication.
- Memory Management: virtual memory, swapping, allocation/de-allocation, paging, segmentation.
- Input-Output: devices, device interface, I/O software.
- File Systems: structure, management, directories, user interface, protection.
- Protection: protection domains, access rights, capabilities.
- Concurrent Programming: synchronization problems, synchronization mechanisms, deadlocks.

#### Suggested references:

1. Silberschatz and Galvin. *Operating Systems Concepts*, 8<sup>th</sup> Edition. Addison-Wesley, 2008.
2. Tanenbaum. *Modern Operating Systems*, 3<sup>rd</sup> Edition. Prentice Hall, 2008.

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPSC 473: Operating Systems Design and Construction

#### Graduate Breadth Course:

CSE 511: Operating System Design

**SUBJECT AREA 8: PROGRAMMING LANGUAGES**

Exam covers the following topics:

- Syntax: context free grammars, parsing [Sethi, Ch. 2].
- Data Types and Representation [Sethi, Ch. 3].
- Procedure Activations: parameter passing mechanisms, scope, activation records [Sethi, Ch. 5].
- Functional Programming: standard ML, higher-order programming, simple and polymorphic types, type inference [Sethi, Ch. 8-9; Reade, Ch 1-3,5].
- Logic Programming: prolog [Sethi, Ch 11].
- Operational Semantics and Type Systems [Sethi, Ch. 13.3; Reade, Ch. 11; lectures notes (last semester of record) for course CMPSC 461.
- Inductive Proofs (Structural Induction) [Reade 3.7, 5.4].
- The Lambda Calculus and the Typed Lambda Calculus [Sethi Ch. 14; Reade Ch. 12].
- Concurrency in Java [Arnold and Gosling Ch. 9].

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPSC 461: Programming Language Concepts

**Suggested references:**

1. Reade. *Elements of Functional Programming*. Addison-Wesley, 1989.
2. Sethi. *Programming Languages: Concepts and Constructs*, 2<sup>nd</sup> Edition. Addison-Wesley, 2006.
3. Arnold and Gosling. *The Java Programming Language*, 3<sup>rd</sup> Edition. Addison-Wesley, 2005.

4. Scott, Michael L. *Programming Language Pragmatics*. Morgan Kaufmann, 20xx.

**Graduate Breadth Courses:**

CSE 520: Science of Computer Programming

**SUBJECT AREA 9: SECURITY**

Exam covers the following topics:

- Security model: goals, definitions.
- Cryptography and Applied Cryptography: symmetric vs. asymmetric, cryptography, hash functions, encryption, MACs, digital signatures.
- Access Control: DAC, MAC, RBAC.
- Security Protocols: Diffie-Hellman, Kerberos, IPsec.
- Network Security: firewalls, DDoS prevention, worms, intrusion detection, sensor network.
- OS Security: UNIX Security, Windows Security, System Security, Principles (Reference Monitoring, Access Matrix, Capabilities, ACLs, System Identity/Authentication).
- Topics: SPAM, policy systems, assurance.

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPSC 443: Introduction to Computer Security

**Suggested references:**

1. Kaufman, C., R. Perlman, M. Speciner. *Network Security (Private Communication in a Public World)*, 2<sup>nd</sup> Edition. Prentice Hall, 2002.
2. Bishop, M. *Computer Security: Art and Science*. Addison-Wesley 2003.

**Graduate Breadth Courses:**

CSE 543: Computer Security

**SUBJECT AREA 10: DIGITAL AND VLSI DESIGN**

Exam covers the following topics:

- Digital integrated circuit design: CMOS Logic and Sequential Design, Arithmetic circuits (adders, multipliers etc), Dynamic and Static Power Optimizations, Timing and clocking Issues. Memory interfaces, SRAM/DRAM/CAM cores, emerging memory technologies, interconnect circuits and optimizations
- Computer Aided Design: Design using Hardware Description languages (e.g., VHDL/Verilog), HDL Design for Synthesis, Design Automation Steps – Synthesis, Placement, Floorplanning etc.
- FPGA Design: FPGA architectures, Performance/Power optimizations for FPGAs, FPGA programming technologies, HDL for FPGA design, Embedded System design using FPGAs.
- Functional Verification: Simulation-based dynamic verification; formal verification; verification methodologies. Dynamic verification, including the basic constructs of stimuli, monitors, checkers, observations categories, assertions, and test benches

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPEN 411: VLSI Digital Circuits  
 CMPEN 417: Digital Design Using Field Programmable Devices  
 CMPEN 475: Functional Verification

**Suggested References:**

1. Digital Integrated Circuits: A Design Perspective, 2nd Ed., J. M. Rabaey, A. Chandrakasan, B. Nikolic, Prentice Hall, 2003.

2. Application-Specific Integrated Circuits, M. J. S. Smith, Addison-Wesley, 1997  
Advanced Digital Design with Verilog HDL, M. Ciletti, Prentice Hall
3. Comprehensive Functional Verification: The Complete Industry Cycle (Systems on Silicon), B. Wile, J. Goss and W. Roesner, Morgan Kaufmann.

#### Graduate Breadth Courses:

- CSE 575: Architecture of Arithmetic Processors  
CSE 577: VLSI Systems Design

#### SUBJECT AREA 11: MACHINE LEARNING

##### Exam covers the following topics:

- Uses of data randomization: Bootstrap aggregation, Permutation tests, Simulations
- Model fitting: Likelihood functions, Regularization, Batch/stochastic/mini-batch gradient descent
- Bayesian Networks: Manipulating conditional probabilities, d-Separation, Parameter estimation
- Additional models and tools: Linear models and support vector machines, Decision trees, Neural networks, Boosting
- Additional AI concepts: Reinforcement learning, A\* search, Genetic algorithms

##### Suggested References:

1. Marsland. *Machine Learning: An Algorithmic Perspective*, CRC Press, 2009.
2. Sutton, Barto. *Reinforcement Learning: An Introduction*, MIT Press,  
<http://webdocs.cs.ualberta.ca/~sutton/book/ebook/the-book.html>
3. Barber. *Bayesian Reasoning and Machine Learning*. Cambridge University Press, 2012  
(<http://web4.cs.ucl.ac.uk/staff/D.Barber/pmwiki/pmwiki.php?n=Brml.HomePage>).

The following Penn State course(s) are recommended as providing a minimal background in the above topics:

CMPSC 448: Machine Learning and Algorithmic AI

#### Graduate Breadth Courses:

- CSE 584: Machine Learning  
STAT/IST 557: Data Mining

## SUMMARY OF GRADUATE DEGREE REQUIREMENTS

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| Requirement   | Person Responsible  | Suggested Completion Dates  | Degree   |
|---|---|---|----------|
| Assign faculty member to serve as tentative faculty advisor.  | Graduate Program Officer  | Early in first semester.  | MS & PhD |
| Recommend faculty members to serve on research committee.   | Student   | End of first semester.  | MS & PhD |
| Prepare a list of courses to comprise graduate plan of study; consult faculty advisor.                                  | Student   | End of first semester.  | MS & PhD |
| Complete doctoral candidacy exam.<br>CSE 591  | Student   | Within first two semesters.   | Ph.D.    |
| Written Examination   | Chairman, Ph.D. Candidacy Examination Committee to conduct examination (student schedules examination). | Must be taken no later than the second regular semester, and completed no later than the third regular semester. (SEE PH.D. CANDIDACY EXAMINATIONS for detailed information). | Ph.D.    |
| Submit plan of study and thesis project proposal to research committee for approval (copy to graduate staff assistant). | Student   | Beginning of third semester.  | M.S.     |
| Recommend faculty members to serve on doctoral research committee.  | Student   | Beginning of first semester after completing candidacy examination.   | Ph.D.    |
| Prepare thesis research project proposal for faculty advisor.   | Student   | Middle of first semester after completing candidacy examination.  | Ph.D.    |
| Submit plan of study and thesis project proposal to research committee for approval (copy to graduate staff assistant). | Student   | Middle of first semester after completing candidacy examination.  | Ph.D.    |

SUMMARY OF DEGREE REQUIREMENTS

| Requirement   | Person Responsible                | Suggested Completion Dates  | Degree         |
|---|-----------------------------------|---|----------------|
| Schedule oral comprehensive examination with graduate staff assistant.  | Student                           | At least four weeks prior to examination date, approved by all committee members.   | Ph.D.          |
| Complete oral comprehensive examination.  | Student to schedule examinations. | Upon substantial completion of coursework, including communications requirements. See advisor on lead time for draft to committee members.<br><b><u>Students must be registered in order to take comprehensive exam.</u></b>                                    | Ph.D.          |
| Inform Graduate Recorder (at the Registrar's Office, 112 Shields) of the intention to graduate.                               | Student                           | Beginning of (or semester just prior to) semester or summer session in which degree is expected.  | All            |
| Pay thesis fee at Registrar's Office.   | Student                           | Beginning of semester or summer session in which degree is expected.  | M.S.,<br>Ph.D. |
| Appropriate completed course requirement sheet checked by PiC, to graduate staff assistant.                                   | Student                           | At least one semester prior to semester in which degree is expected.  | All            |
| Submit draft copy of thesis to faculty advisor.   | Student                           | Early in last semester.   | M.S.,<br>Ph.D. |
| Distribute copies of thesis to each committee member and graduate coordinator.  | Student                           | AFTER thesis has been approved by faculty advisor.  | M.S.,<br>Ph.D. |
| Schedule final oral examination for M.S. Thesis with graduate staff assistant.  | Student                           | At least one week prior to scheduled examination date, on approval by all committee members.  | M.S.           |
| Schedule final oral examination for Ph.D. Thesis with graduate staff assistant.   | Student                           | At least four weeks prior to scheduled examination date, on approval by all committee members. Check with advisor for lead time on submitting draft to committee members.<br><b><u>Students must be registered in order to defend a Ph.D. dissertation.</u></b> | Ph.D.          |
| Complete final oral examination.  | Student                           | As soon as faculty advisor approves thesis for oral examination. Early enough for final draft of thesis to be submitted before deadline date.   | M.S.,<br>Ph.D. |
| Return departmental keys and any books, software, supplies, etc., as required, to Administrative Assistant or as appropriate. | Student                           | Prior to departure  | All            |



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## COURSE OFFERINGS

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The Course Offerings list will be constantly monitored and updated as needed; the following is a list of graduate level departmental courses as they currently exist. It should also be noted that the department offers individual study courses that can include creative projects, including nonthesis research, that are supervised on an individual basis and that fall outside the scope of a formal course; and special topics courses that are formal courses meant to explore, in depth, a subject that may be topical or of special interest. There are several 600 level (research/thesis) courses offered.

Disclaimer: Please note that, except for certain pre-major entry courses available to the exploratory students in DUS and ENGR, many CMPSC, CMPEN, and CSE courses are controlled for students in the Computer Science or Computer Engineering major. Certain majors have negotiated with the department of computer science and engineering to allow their students to register for CMPSC, CMPEN, and CSE courses as part of a computational option. Students outside those majors, however, will find it difficult and probably impossible to schedule CMPSC, CMPEN, and CSE courses. Therefore, students should not pursue another major with the thought that they will be able to compliment it with CMPSC, CMPEN, and CSE electives.

**CMPSC 431W – DATABASE MANAGEMENT SYSTEMS (3)** Topics include: conceptual data modeling, relational data model, relational query languages, schema normalization, database/Internet applications, and database system issues. Prerequisite: CMPSC 221; ENGL 202C.

**CMPSC 442 – ARTIFICIAL INTELLIGENCE (3)** Introduction to the theory, research paradigms, implementation techniques, and philosophies of artificial intelligence. Prerequisite: CMPSC 122 or equivalent. Concurrent: CMPSC 465.

**CMPSC 443 – INTRODUCTION TO COMPUTER AND NETWORK SECURITY (3)** Introduction to theory and practice of computer security with an emphasis on Internet and operating system applications. Prerequisite: CMPSC 473, CMPEN 362.

**CMPSC 448 – MACHINE LEARNING AND ALGORITHMIC AI (3)** Evaluation and use of machine learning models; algorithmic elements of artificial intelligence. Prerequisite: STAT 319 or STAT 415 and CMPSC 122 or prior programming experience.

**CMPSC 450 – CONCURRENT SCIENTIFIC PROGRAMMING (3)** Problems of synchronization, concurrent execution, and their solution techniques. Design and implementation of concurrent software in a distributed system. Prerequisite: CMPSC 121, CMPSC 201 or CMPSC 202; MATH 220; MATH 230 or MATH 231.

**CMPSC 451 (MATH 451) – NUMERICAL COMPUTATIONS (3)** Algorithms for interpolation, approximation, integration, nonlinear equations, linear systems, fast FOURIER transform, and differential equations emphasizing computational properties and implementation. Students may take only one course for credit from CMPSC/MATH 451 and CMPSC/MATH 455. Prerequisite: 3 credits of programming; MATH 230 or MATH 231.

**CMPSC 455 (MATH 455) – INTRODUCTION TO NUMERICAL ANALYSIS I (3)** Floating point computation, numerical rootfinding, interpolation, numerical quadrature, direct methods for linear systems. Students may take only one course for credit from MATH 451 and MTHBD 423. Prerequisite: MATH 220; MATH 230 or MATH 231; and 3 credits of programming.

**CMPSC 456 (MATH 456) – INTRODUCTION TO NUMERICAL ANALYSIS II** (3) Polynomials and piecewise polynomial approximation; matrix least square problems; numerical solution of eigenvalue problems; numerical solutions of ordinary differential equations. Prerequisite: CMPSC 455.

**CMPSC 458 – FUNDAMENTALS OF COMPUTER GRAPHICS** (3) Fundamentals of computer graphics: input/output devices, transformation, projection, clipping, hidden line/surface elimination. Prerequisite: CMPSC 311; MATH 220; MATH 230 OR MATH 231.

**CMPSC 461 – PROGRAMMING LANGUAGE CONCEPTS** (3) Fundamental principles of computer language design, stressing the relationship between design and implementation. In-depth study of a few representative languages. Prerequisite: CMPSC 221; CMPSC 360.

**CMPSC 464 – INTRODUCTION TO THE THEORY OF COMPUTATION** (3) This course introduces automata, formal languages and computability, including regular and context-free languages, and undecidable and NP-complete problems. Prerequisite: CMPSC 465.

**CMPSC 465 – DATA STRUCTURES AND ALGORITHMS** (3) Fundamental concepts of computer science: data structures, analysis of algorithms, recursion, trees, sets, graphs, sorting. Prerequisite: CMPSC 122; CMPSC 360 or MATH 311W.

**CMPSC 467 (MATH 467) – FACTORIZATION AND PRIMALITY TESTING** (3) Prime sieves, factoring, computer numeration systems, congruences, multiplicative functions, primitive roots, cryptography, quadratic residues. Students who have passed MATH 465 may not schedule this course. Prerequisite: CMPSC 360 or MATH 311W.

**CMPSC 471 – INTRODUCTION TO COMPILER CONSTRUCTION** (3) Design and implementation of compilers; lexical analysis, parsing, semantic

actions, optimization, and code generation. Prerequisite: CMPSC 461.

**CMPSC 473 – OPERATING SYSTEMS DESIGN AND CONSTRUCTION** (3) Design and implementation of computer operating systems; management of various system resources: processes, memory, processors, files, input/output devices. Prerequisite: CMPSC 311 and CMPEN 331.

**CMPSC 475 APPLICATIONS PROGRAMMING** (3) Development of software for devices including smart phones, tablets, handheld units, and other general purpose computing platforms. Prerequisite: CMPSC 221 or CMPSC 425; CMPSC 311 or CMPSC 312; CMPSC 462 or CMPSC 465

**CMPSC 483W – SOFTWARE DESIGN METHODS** (3) Applications of scientific knowledge and methods in the design and construction of computer software using engineering concepts. Prerequisite: CMPSC 221, CMPSC 465, ENGL 202C.

**CMPEN 411 – VLSI DIGITAL CIRCUITS** (3) Basic building blocks of CMOS design, design rules, chip planning, layout design, system power and timing, simulation of VLSI structures. Prerequisite: CMPEN 371 or CMPEN 471; EE 310.

**CMPEN 416 (EE 416) – DIGITAL INTEGRATED CIRCUITS** (3) Analyses and design of digital integrated circuit building blocks, including logic gates, flip-flops, memory elements, analog switches, multiplexers, and converters. Prerequisite: EE 310.

**CMPEN 417 (EE 417) – DIGITAL DESIGN USING FIELD PROGRAMMABLE DEVICES** (3) Field programmable device architectures and technologies; rapid prototyping using top down design techniques; quick response systems. Prerequisite: CMPEN 331.

**CMPEN 431 – INTRODUCTION TO COMPUTER ARCHITECTURE (3)** Introduction to computer architecture. Memory hierarchy and design, CPU design, pipelining, multiprocessor architecture. Prerequisite: CMPEN 331 or CMPEN 371.

**CMPEN 454 (EE 454) – FUNDAMENTALS OF COMPUTER VISION (3)** Introduction to topics such as image formation, segmentation, feature extraction, matching, shape recovery, object recognition, and dynamic scene analysis. Prerequisite: MATH 230 or MATH 231; CMPSC 121 or CMPSC 201.

**CMPEN 455 (EE 455) – DIGITAL IMAGE PROCESSING (3)** Overview of digital image processing techniques and their applications, image sampling, enhancement, restoration, and analysis; computer projects. Prerequisite: EE 353 or EE 350; CMPSC 121 or CMPSC 201.

**CMPEN 471 – LOGICAL DESIGN OF DIGITAL SYSTEMS (3)** Basic switching theory and design of digital circuits, including combinational, synchronous sequential, and asynchronous sequential circuits. Prerequisite: CMPEN 331.

**CMPEN 472 – MICROPROCESSORS AND EMBEDDED SYSTEMS (3)** Microprocessors: architecture, design, assembly language, programming, interfacing, bus structure, and interface circuits and their use in embedded systems. Prerequisite: CMPEN 331.

**CMPEN 473 – MICROCOMPUTER LABORATORY (3)** Design of digital systems using microprocessors. Prerequisite: CMPEN 472.

**CMPEN 475 – FUNCTIONAL VERIFICATION (3)** Introduce concepts, methods, and technology for effective functional verification of modern electronic systems. Prerequisite: CMPEN 331.

**CMPEN 482W – COMPUTER ENGINEERING PROJECT DESIGN (3)** Computer engineering design project, project management, documentation, reporting, and group and individual communication skills. Prerequisite: EE 310, EE 353, CMPSC 473, ENGL 202C.

**CSE 511. OPERATING SYSTEM DESIGN (3)** Concurrent programming; design of I/O subsystem, memory management, and user interface; kernel design; deadlocks, protection and security; case studies. Prerequisite: CMPSC 473.

**CSE 513 – DISTRIBUTED SYSTEMS (3)** Protocol hierarchies; routing and flow control algorithms; distributed operating systems; communication and synchronization mechanisms; resource allocation problems. Prerequisite: CMPSC 473.

**CSE 514. COMPUTER NETWORKS (3)** Network subsystems, ARPANET, SNA, DECNET, network protocols (physical databank, network, transport, sessions, presentation, application), routing and congestion control, network optimization. Prerequisite: CMPEN 362; EE 353 or EE 350.

**CSE 515 (EE 565). RELIABLE DATA COMMUNICATIONS (3)** Discussion of problems and solutions for ensuring reliable and efficient communication over wired and wireless links and data networks. Prerequisites: STAT/MATH 418.

**CSE 516. MOBILE NETWORKING (3)** Algorithms, systems and design of mobile telecommunication voice and data networks.

**CSE 517. PERFORMANCE EVALUATION (3)** Tools and techniques for PE, analytical and simulation models, evaluation of multiprocessors, multicomputer and LANs, scheduling policies, case studies.

**CSE 520. SCIENCE OF COMPUTER PROGRAMMING** (4) Weakest preconditions, nondeterminism, terminating constructs, formal derivation of some often used algorithms, correctness of programs, formal specification of large systems. Prerequisite: CMPSC 461.

**CSE 521. COMPILER CONSTRUCTION** (3) Design and implementation of compilers.

**CSE 522. SEMANTICS OF PROGRAMMING LANGUAGES** (3) Operational, axiomatic, and denotational semantics of programming languages; fixpoint theory of computation, verification of recursive programs; goto statements and continuations. Prerequisite: CMPSC 461.

**CSE 530. FUNDAMENTALS OF COMPUTER ARCHITECTURE** (3) Advances in computer architecture, Pipelining, parallelism and multiprocessing. Prerequisite: CMPEN 431.

**CSE 531. PARALLEL PROCESSORS AND PROCESSING** (3) Parallel processor organization; basic algorithms suitable for such systems; parallel sorting and interconnection networks; applications and discussion of specific processors. Prerequisite: CSE 530.

**CSE 532. MULTIPROCESSOR ARCHITECTURE** (3) Fundamental structures of multiprocessors; interprocess communications; system deadlocks and protection, scheduling strategies, and parallel algorithms; example multiprocessor systems. Prerequisite: CSE 530.

**CSE 536. FAULT TOLERANT SYSTEMS** (3) Attributes of fault-tolerant systems and their definitions; reliability and availability techniques; maintainability and testing techniques; practice of reliable system design. Prerequisite: CSE 530.

**CSE 537. INTERCONNECTION NETWORKS IN HIGHLY PARALLEL COMPUTERS** (3) Study and comparative analysis of various classes of interconnection networks; routing problems; fault tolerance issues; performance evaluation; VLSI implementation. Prerequisite: CSE 530.

**CSE 539. TOPICS IN COMPUTER ARCHITECTURE** (3) Study of current advanced issues in design, implementation and applications of complex computer system. Prerequisite: CSE 530.

**CSE 541. DATABASE SYSTEMS I** (3) Data models and relational database design; database integrity and concurrency control; distributed database design and concurrency control; query optimization. Prerequisite: CMPSC 431W.

**CSE 543. COMPUTER SECURITY** (3) Specification and design of secure systems; security models, architectural issues, verification and validation, and applications in secure database management systems. Prerequisite: CMPSC 461.

**CSE 544. SYSTEM SECURITY** (3) Review current research in computer and operating system security. Prerequisite: CMPEN 362, CMPSC 473, CSE 543.

**CSE 545. NETWORK SECURITY** (3) Advanced methods and technologies for network security. Prerequisite: CSE 543.

**CSE 546. CRYPTOGRAPHY** (3) Introduction to the theory and techniques of modern cryptography, with emphasis on rigorous analysis and mathematical foundations. Prerequisite: CMPSC 465.

**CSE 550 (MATH 550). NUMERICAL LINEAR ALGEBRA** (3) Solution of linear systems, sparse matrix techniques, linear least squares, singular value decomposition, numerical computation of eigenvalues and eigenvectors. Prerequisite: CMPSC 456 or MATH 441.

**CSE 551 (MATH 551). NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS** (3) Methods for initial value and boundary value problems. Convergence and stability analysis, automatic error control, stiff systems, boundary value problems. Prerequisite: CMPSC (MATH) 451 or CMPSC (MATH) 456.

**CSE 552 (MATH 552). NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (3)**

Finite difference methods for elliptic, parabolic, and hyperbolic differential equations; solutions techniques for discretized systems; finite element methods for elliptic problems. Prerequisite: CMPSC (MATH) 451 or CMPSC (MATH) 456; MATH 402 or MATH 404.

**CSE 553 (MATH 553). INTRODUCTION TO APPROXIMATION THEORY (3)**

Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisite: MATH 401; 3 credits in Computer Science and Engineering.

**CSE 554 (EE 564). ERROR CORRECTING CODES FOR COMPUTERS AND COMMUNICATION (3)**

Block, cyclic and convolutional codes. Circuits and algorithms for decoding. Application to reliable communication and fault-tolerant computing. Prerequisite: CMPEN 362.

**CSE 555 (MATH 555). NUMERICAL OPTIMIZATION TECHNIQUES (3)**

Unconstrained and constrained optimization methods, linear and quadratic programming, software issues, ellipsoid and Karmarkar's algorithm, global optimization, parallelism in optimization. Prerequisite: CMPSC (MATH) 456.

**CSE 556 (MATH 556). FINITE ELEMENT METHODS (3)**

Sobolev spaces, variational formulations of boundary value problems; piecewise polynomial approximation theory, convergence and stability, special methods and applications. Prerequisite: MATH 502, MATH 552.

**CSE 557. CONCURRENT MATRIX COMPUTATION (3)**

This course discusses matrix computations on architectures that exploit concurrency. It will draw upon recent research in the field. Prerequisites: Either CMPSC 451, CMPSC 455, CMPSC 450, MATH 451 or MATH 455.

**CSE 560. THEORY OF GRAPHS AND NETWORKS (3)**

Theory and applications of graphs, including structure of graphs, network analysis, and algorithms for computer solution of graph-theoretic problems. Prerequisite: CSE 565.

**CSE 562. PROBABILISTIC ALGORITHMS (3)**

Design and analysis of probabilistic algorithms, reliability problems, probabilistic complexity classes, lower bounds. Prerequisite: CSE 565.

**CSE 564. COMPLEXITY OF COMBINATORIAL PROBLEMS (3)**

NP-completeness theory; approximation and heuristic techniques; discrete scheduling; additional complexity classes. Prerequisite: CSE 565.

**CSE 565. ALGORITHM DESIGN AND ANALYSIS (3)**

An introduction to algorithmic design and analysis. Prerequisite: CMPSC 465. Concurrent: CMPSC 468.

**CSE 566 (BMMB 566). Algorithms and Data Structures in Bioinformatics (3)**

Covers elegant algorithmic and data structure techniques that underpin modern biological data analysis. Prerequisite: CMPSC 465.

**CSE 572. MICROPROCESSORS AND SYSTEMS DESIGN (3)**

Contemporary design issues in microprocessors, including advanced features and system integration issues. Prerequisite: CMPEN 431, CMPEN 472.

**CSE 575. ARCHITECTURE OF ARITHMETIC PROCESSORS (3)**

Algorithms and techniques for designing arithmetic processors; conventional algorithms and processor design; high-speed algorithms and resulting architectural structures. Prerequisite: CMPEN 411.

**CSE 577. VLSI SYSTEMS DESIGN (3)**

Engineering design of large-scale integrated circuits, systems, and applications; study of advanced design techniques, architectures, and CAD methodologies. Prerequisite: CMPEN 411.

**CSE 578. VLSI COMPUTER-AIDED DESIGN TOOLS (3)** VLSI circuit design tools: placement, routing, extraction, design rule checking, graphic editors, simulation, verification, minimization, silicon compilation, test pattern generation. Prerequisite: CMPEN 411.

**CSE 579. TOPICS IN COMPUTER HARDWARE DESIGN (3)** Computer hardware design; emerging technologies in hardware design; new challenges for nano-scale VLSI design. Prerequisite: CMPEN 411 and CMPEN 431.

**CSE 583 (EE 552). PATTERN RECOGNITION – PRINCIPLES AND APPLICATIONS (3)** Decision-theoretic classification, discriminant functions, pattern processing and feature selection, syntactic pattern recognition, shape analysis and recognition.

**CSE 584 (STAT 584). Machine Learning: Tools and Algorithms (3)** Computational methods for modern machine learning models, including applications to big data and non-differentiable objective functions.

**CSE 585 (EE 555). DIGITAL IMAGE PROCESSING II (3)** Advanced treatment of image processing techniques; image restoration; image segmentation, texture, and mathematical morphology. Prerequisite: CMPEN 455 or EE 455.

**CSE 586 (EE 554). TOPICS IN COMPUTER VISION (3)** Discussion of recent advances and current research trends in computer vision theory, algorithms, and their applications. Prerequisite: CMPEN 454 or EE 454.

**CSE 588 (MATH 588). COMPLEXITY IN COMPUTER ALGEBRA (3)** Complexity of integer multiplication, polynomial multiplication, fast Fourier transform, division, and calculating the greatest common divisor of polynomials. Prerequisite: CMPSC 465.

**CSE 590. COLLOQUIUM (1-3)** Continuing seminars that consist of a series of individual lectures by faculty, students, or outside speakers.

**CSE 591. RESEARCH EXPERIENCE IN COMPUTER SCIENCE AND ENGINEERING (1)** Research experience for new doctoral students in Computer Science and Engineering. Research is performed in conjunction with another 500-level CSE course. Concurrent: enrollment in another 500-level CSE course.

**CSE 594. RESEARCH TOPICS (1-15)** Supervised student activities on research projects identified on an individual or small-group basis.

## POLICIES AND PROCEDURES – GENERAL INFORMATION

### Computer Facilities and Their Use

The department of computer science and engineering maintains 7 specialized computing labs for graduate/undergraduate instruction and 11 experimental labs for research purposes. The labs host diverse infrastructures that are configured specifically to meet curricular and research goals. All computational resources, including HPC, storage, visualization, and virtualized systems, are interconnected with GigE service to Penn State's campus backbone. The campus backbone provides access to Internet, I2, Lambda Rail, and other high speed networks.

Penn State's Information Technology Services (ITS) provides centralized computing facilities for many aspects of university life. The student computing labs at University Park are available to faculty, staff, and students. There are over fifty computer labs and classrooms with nearly 3,000 computers in 322 rooms on the University Park campus, as well as over 1,000 mobile computing ports that provide users with workstations and peripherals for Windows, Macintosh, and Unix platforms.

The labs have any combination of Windows, Macintosh, or Linux systems. They are equipped with printers and scanners, as well as more specialized hardware such as digital cameras and CD burners. To learn more about ITS services, please visit their website: <http://its.psu.edu/>.

### Employment

A student holding a fellowship or scholarship may not accept employment of any kind for service beyond that specifically permitted by the appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the head of

the department providing the assistantship and from the person in charge of the assistant's graduate program. A graduate assistant may not hold a concurrent appointment with the University other than a Fellowship Supplement. A foreign student may not work more than twenty hours a week, regardless of whether it is on- or off-campus employment.

### Health Insurance

Health insurance is required for all graduate assistants. ALL international students are required to have health insurance; coverage must be purchased for their spouses and children, as well. For domestic graduate assistants, health insurance is optional. The University will pay a percentage of the annual premium for the Penn State Student Health Insurance Plan for graduate assistants. The remaining percentage will be automatically deducted from the student's assistantship stipend. The University will not supplement, nor will a payroll deduction be made, for insurance policies other than the Penn State Student Insurance Plan. A waiver may be obtained by providing the Student Insurance Office proof of adequate alternate insurance. Failure to comply may result in University sanctions. There is a \$100 late fee for students who fail to comply with the mandatory health insurance requirement on time. **For more information about University Health Services and student health insurance, please go to:** <http://studentaffairs.psu.edu/health/services/insurance/>

## Keys

Keys will be issued to an assigned office or research lab. **No key is to be transferred from one person to another; they *must be* returned to the key custodian.** All keys must be returned upon termination. Keys are processed in W360 Westgate Building.



## Mailboxes

All CSE graduate students are assigned mailboxes in W106 Westgate Building. The assignment will be made after the start of classes; mail will be held for you if it arrives before the mailbox is available.

## Office Assignments

Office assignments are made only to students holding a fellowship, or a research assistantship. Offices are reassigned each fall semester and are not held over the summer session for students not registered for the summer. TA's will have access to space to hold office hours

## Parking

Specific regulations govern student vehicle registration and parking privileges. All students, regardless of classification, must register their automobiles, bicycles, and mopeds. Students must also comply with Pennsylvania provisions, as well as University provisions, when operating a vehicle on campus. Parking lots are reserved. Students may obtain instructions about vehicle registration, use, and parking directly from the Parking Office in 1 Eisenhower Parking Deck (814-865-1436) at University Park and from the Office of Student Affairs at all other campuses.

## Recycling

It is the policy of the University that all faculty, staff, students and visitors comply with applicable federal, state, and local laws regarding the general reduction of specified materials for later collection and reuse for the purpose of protecting the environment and reducing the amount of solid waste deposited to landfills by the University.

## Registration Responsibilities

It is the responsibility of the student, in consultation with their advisor, to be properly registered. A student is expected to complete registration during the officially designated period

and to attend the first meeting of all classes. A student who fails to complete the process of registration within the officially designated registration period will be liable for a late charge.

## Smoking Policy

Smoking of any material is prohibited in all University facilities, at all locations, including University-owned vehicles.

## Standards of Conduct

Graduate students are expected to have learned the meaning and value of personal honesty and professional integrity before entering the Graduate School. Every student is expected to exhibit and promote the highest ethical and moral standards. A violation of such standards is regarded as a serious offense, raising grave doubt that the student is worthy of continued membership in the Graduate School community. Violation of the University Code of Conduct may result in suspension or dismissal from the academic program and/or from the Graduate School. The Code of Conduct behaviors include, but are not limited to:

1. **ABUSE/ENDANGERMENT/HAZING OF A PERSON:** Physically harming or threatening to harm any person, intentionally or recklessly causing harm to any person or reasonable apprehension of such harm or creating a condition that endangers the health and safety of self or others, including through the facilitation of or participation in any mental or physical hazing activity.
2. **SEXUAL MISCONDUCT OR ABUSE:** The University does not tolerate sexual misconduct or abuse, such as sexual assault, rape or any other forms of nonconsensual sexual activity. Sexual misconduct and abuse can occur between acquaintances or parties unknown to each other. Sexual abuse is attempted or actual unwanted sexual activity, such as sexual touching and fondling. This includes the

touching of an unwilling person's intimate parts (defined as genitalia, groin, breast or buttock, or clothing covering them), or forcing an unwilling person to touch another's intimate parts. Sexual misconduct includes, but is not limited to, sexual assault, rape, forcible sodomy or sexual penetration with an inanimate object, intercourse without consent, under conditions of force, threat of force, fear or when a person is unable to give consent because of substance abuse, captivity, sleep or disability (also see [Policy AD-85](#)).

3. **HARASSMENT:** Harassment is behavior that is sufficiently severe or pervasive so as to threaten an individual or substantially interfere with the individual's employment, education or access to University programs, activities or opportunities, and that would detrimentally affect a reasonable person under the same circumstances. Behaviors that meet the above definition may include, but are not limited to, the following:
  - directing physical or verbal conduct at an individual because of the individual's age, ancestry, color, disability or handicap, national origin, race, religious creed, sex, sexual orientation, gender identity or veteran status (see [AD-91](#));
  - subjecting a person or group of persons to unwanted physical contact or threat of such;
  - engaging in a course of conduct, including following the person without proper authority, under circumstances which demonstrate intent to place the other person in reasonable fear of bodily injury or to cause the other person substantial emotional distress (see [AD-85](#));
  - or harassment of a sexual nature as described (see [AD-91](#)).
4. **WEAPONS, FIREARMS, AND PAINTBALL DEVICES:** The possession, storing, carrying, or use of any weapon, ammunition, or explosive by any person is prohibited on all University property except by authorized law enforcement officers and other persons specifically authorized by the University. No person shall possess, carry, or use any fireworks on University property, except for those persons authorized by University and local governments to discharge such fireworks as part of a public display. Paintball guns and paintball markers may only be used on the property of the University in connection with authorized University activities and only at approved locations (also see [SY-12](#)).
5. **FIRE SAFETY VIOLATIONS:** Tampering with fire or other safety equipment or setting unauthorized fires.
6. **ALCOHOL AND/OR DRUGS:** Illegally possessing, using, distributing, manufacturing, selling or being under the influence of alcohol or other drugs. Use, possession or distribution of beverages containing alcohol on University property shall comply with the laws of the Commonwealth of Pennsylvania and University Policies and Rules. Note: Anyone, including those under 21, serving alcohol to persons under 21 is in violation of both University regulations and state law. Excessive consumption occurs when a person is intoxicated to the degree that the person may endanger self, other persons, or property, or annoy persons in the vicinity. (also see [Policies AD-18, AD-33](#)). It is also a violation of the residence hall contract for a student to be in the presence of the presence of the use of illegal drugs or if under 21 years of age, alcohol, in any residential area.
7. **FALSE INFORMATION:** Intentionally providing false or inaccurate information or records to University or local authorities. Providing a false report of an emergency, University rule and/or Code violation. Knowingly providing false statements or testimony during a University investigation or proceeding.

8. **THEFT AND OTHER PROPERTY OFFENSES:** Stealing, vandalizing, damaging, destroying, or defacing University property or the property of others.
9. **DISRUPTION OF OPERATIONS:** Obstruction or disruption of classes, research projects, or other activities or programs of the University; or obstructing access to University facilities, property, or programs. Disruption is defined as an action or combination of actions by one or more individuals that unreasonably interferes with, hinders, obstructs, or prevents the operation of the University or infringes on the rights of others to freely participate in its programs and services.
10. **VIOLATIONS OF ACADEMIC INTEGRITY:** Academic integrity is the pursuit of scholarly activity in an open, honest and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle. Consistent with this expectation, students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts. Academic integrity includes a commitment not to engage in or tolerate acts of falsification, misrepresentation or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others (see [Faculty Senate Policy 49-20](#) and [G-9 Procedures](#)).
11. **FAILURE TO COMPLY:** Failing to comply with reasonable directives from University or other officials when directed to do so. Failure to provide identification or to report to an administrative office or, when reasonable cause exists, failing to leave University-controlled premises or dangerous situations when directed to do so by properly authorized persons, including police and/or other University staff. This charge may be added to other charges, e.g., when a student fails to leave a residence hall during a fire drill and refuses to leave when directed to do so by a University official.
12. **FORGERY/ALTERATION:** Making, using or possessing any falsified University document or official record; altering or forging any University document or record, including identification, meal or access cards. This includes but is not limited to; forging (signing another's name and/or ID number) key request forms, manufacturing IDs or tickets, altering permits, misuse of forms (letterhead stationery, University forms), and keys to mislead.
13. **UNAUTHORIZED ENTRY OR USE:** Unauthorized entry into or use of property or University facilities including residence halls, classrooms, offices, and other restricted facilities. Unauthorized entry or use of facilities is referred to in the University policy regarding the rights of individuals and the rights of the institution. Specifically, policy refers to an "obligation not to infringe upon the rights of all members of the campus to privacy in offices, laboratories and residence hall rooms, and in the keeping of personal papers, confidential records and effects, subject only to the general law and University regulations." The University also has the right to control use and entry into facilities for reasons of security, safety or protection of property. This includes closing facilities at specified times. It should also be recognized that an open or unlocked door is not an invitation to enter and use facilities. The same concept applies to computer entry or misuse, including violation of any University computer policy (also see [Policy AD-20](#)).
14. **DISORDERLY CONDUCT:** Engaging in disorderly, disruptive, lewd or indecent conduct. The item includes but is not limited to: inciting or participating in a riot or group

disruption; failing to leave the scene of a riot or group disruption when instructed by officials; disruption of programs, classroom activities or functions and processes of the University; creating unreasonable noise; or creating a physically hazardous or physically offensive condition.

15. VIOLATIONS OF UNIVERSITY

REGULATIONS: Violating written University policy or regulations contained in any official publications, administrative announcements, contracts and/or postings.

16. VIOLATION OF LAW: When it is established that a student has violated federal, state, or local law and the violation of law affects a Substantial University Interest, the student may be charged within the Code of Conduct for Violation of Law.

### Stipends

All graduate appointees are paid monthly. Direct salary deposits are mandatory and a condition of hire.

### Background Checks

All employees of the University, including Graduate Assistants and wage payroll graders and learning assistants must have a background check completed by the University. This is a requirement for employment. There is no cost to the student for this check. The student may not begin work until the background check is completed.

### Travel

Travel to professional meetings for graduate students in the final year of their Ph.D. program may be partially supported by the department. The student should make the travel request to the department head. The maximum level of support will be \$500 during the last academic year of residency of the student. Please see Amy Hasan in W311 Westgate Building for more information about department travel funds for graduate students.

All student travel on University business and paid from University funds is subject to strict mandatory policies. BEFORE travel, students must discuss travel policies with members of our Finance Office (Annie Royer or Crystal Rearick).

## PERSONNEL SUPPORT

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**Katelen Bair** (undergraduate staff assistant): Maintain and secure all undergraduate records, assign advisors, advise students and review individual requirement sheets, record grades, assist with processing all changes for the curriculum through the Faculty Senate, course scheduling, and room scheduling. (865-9191; kdb18@psu.edu)

**Amanda Choy** (staff assistant for undergraduate support): First point of contact in the curricular affairs office and front desk to assist students and faculty, answer telephone, create departmental technical reports, process UPS mailings, coordinates printing and duplication projects for faculty. Assists with course and classroom scheduling and processes drop/adds for students. Assists with departmental event planning. (865-9235; arc88@psu.edu)

**Bekka Coakley** (marketing and communications specialist): Edit and coordinate production of various department publications; department photography; prepare press releases and news articles; maintain social media websites; maintain web content. (867-6229; rac29@psu.edu)

**John Domico** (assistant director of information systems): Budget planning for academic and research systems, direction of systems staff and CSE's systems, liaison for collaborative systems projects. Strategize and plan deployment of emerging technologies that support research and curriculum. (865-3757; domico@cse.psu.edu)

**Barbara Einfalt** (intermediate database/analyst programmer): Create and maintain user accounts. Responsible for the development and administration of a department database. (865-1167; beinfalt@cse.psu.edu)

**Amy Hasan** (manager, department administrative operations; administrative assistant): Budget planning, reporting and development of departmental budgets, and oversees research grant budgets and contract management. Supervisor of administrative support staff; oversees scholarship coordination. (865-9189; alh31@psu.edu)

**Sharon Elder** (staff assistant to the department head): Maintains department head's calendar; assist with faculty recruiting; schedule committee meetings; (863-1242; sle9@psu.edu)

**Kem Hartley** (network systems specialist): Responsible for administration and support of CSE's Windows-based systems. Configure hardware and software images for telecommunications and other equipment; physical inventory; card readers. (867-1947; kdh162@cse.psu.edu)

**Jennifer Houser** (staff assistant to the graduate program officer, staff assistant for the M. Engr. program): Maintain and secure graduate student records; process graduate appointments, and all aspects of graduate student support. Coordinates candidacy exams for doctoral candidates, schedules and tracks SARI requirements (research integrity). Runs graduate degree audits. (865-9186; jjh2@psu.edu)

**Beth Kennedy** (staff assistant-facilities) Maintain and assign keys; coordinate colloquia; parking chairperson, facilities coordinator. (867-2360; bau1@psu.edu)

**Cindy Milliron** (staff assistant for graduate support): Serves graduate students, process drop/adds, grad applications, and supporting documents; order textbooks for faculty; prepare office/telephone directory. Serves as general department support and back up to the graduate assistant and front desk staff. (865-1582; c1m39@psu.edu)

**Eric Prescott** (systems administrator III): Responsible for operations and support of research equipment; administrative support of departmental Linux machines. (863-1142; prescott@cse.psu.edu)

**Crystal Rearick** (staff assistant for budget support): Wage payroll coordinator, travel reimbursements; purchasing card charges; scholarships. (865-4007; cdf117@psu.edu)

**Annie Royer** (budget staff assistant): Travel reimbursements, purchasing cards, coordinates office supplies and paper supply for labs, orders equipment; orders caps and gowns for faculty. (865-9188; acr13@psu.edu)

**Mark Tamminga** (senior systems administrator): Responsible for enterprise storage, virtualization and Microsoft OS applications. His work supports research, teaching, and administrative systems. (867-1780; tamminga@cse.psu.edu)

**Tony Vallalla** (senior systems analyst): Responsible for the operation of all systems that use Microsoft operating systems and applications. His work supports research, teaching, and administrative systems. (865-1040; vallalla@cse.psu.edu)

**Loretta Whitman** (grants and contracts assistant): Updates and maintains vitae for all faculty; promotion and tenure; prepares annual self-activity reports for all faculty, prepares budgets and assists with grant submissions, prepares documents for student fellowship/grant submissions. (865-7152; luw92@psu.edu)

# APPENDIX I

## GENERAL STANDARDS OF PROFESSIONAL ETHICS

### PURPOSE:

To set forth statements of general standards of professional ethics to serve as a reminder of the variety of obligations assumed by all members of the academic community

### STATEMENTS:

- I. Professors, guided by a deep conviction of the worth and dignity of the advancement of knowledge, recognize the special responsibilities placed upon them. Their primary responsibility to their respective subjects is to seek and to state the truth as they see it. To this end, they devote their energies to developing and improving their scholarly competence. They accept the obligation to exercise critical self-discipline and judgment in using, extending, and transmitting knowledge. They practice intellectual honesty. Although they may follow subsidiary interests, these interests must never seriously hamper or compromise their freedom of inquiry.
- II. As teachers, professors encourage the free pursuit of learning in their students. They hold before their students the best scholarly standards of their respective disciplines. They demonstrate respect for the student as an individual, and adhere to their proper role as intellectual guides and counselors. They make every reasonable effort to foster honest academic conduct and to assure that their evaluations of students reflect the students' true merit. They respect the confidential nature of the relationship between professor and student. They avoid any exploitation of students for private advantage and acknowledge significant assistance from them. They protect their students' academic freedom.
- III. As researchers/scholars, professors recognize that their goal is to discover, develop, and communicate new understanding. This goal is rarely achieved without making use of knowledge gained from others. Researchers must always exercise gracious and appropriate recognition of published work in the literature, conversations with colleagues, and the efforts of students who work under the researchers' guidance. They must be scrupulous in presentation of their own data; it must be verifiable as a result of the highest standards in data gathering techniques. They must be extremely careful in the use of data reported by others, especially if used in the formation of broad comparative or contradictory hypotheses, since they may not know of any compromising circumstances in such data gathering. They must be comprehensive in consideration of work with human subjects; they must have thoroughly researched all procedures, must have informed individuals involved of all aspects of their cooperation, and must report all responses accurately, both positive and negative results. As open-minded researchers, when evaluating the work of others, they must recognize the responsibility to allow publication of theories or experiments that may contradict their own findings, as only by free inquiry and dissemination of all facts will the fruits of the labor of the whole community be allowed to mature.
- IV. As colleagues, professors have obligations that derive from common membership in the community of scholars. They respect and defend the free inquiry of their associates. In the exchange of criticism and ideas they show due respect for the opinions of others. They acknowledge their academic debts and strive to be objective in their professional judgment of colleagues. They accept their share of faculty responsibilities for the governance of their institution.
- V. As members of their institution, professors seek above all to be effective teachers and scholars. Although they observe the stated regulations of the institution, provided the regulations do not contravene academic freedom, they maintain their rights to criticize and seek revision. They determine the amount and character of the work they do outside their institution with due regard to their paramount responsibilities within it. When considering the interruption or termination of their service, they recognize the effect of this decision upon the programs of the institution and give due notice of their intentions.
- VI. As members of the community, professors have the rights and obligations of all citizens. They measure the urgency of these obligations in the light of their responsibilities to their respective subjects, to their students, to their profession, and to their institution. When they speak or act as private persons they avoid creating the impression that they speak or act for their respective colleges or the University. As citizens engaged in a profession that depends upon freedom for its health



and integrity, professors have an articular obligation to promote conditions of free inquiry and to further public understanding of academic freedom.

All tangible assets (including equipment, software, audio-visual material, theatrical costumes, etc.) owned, leased or operated by the University are to be used in the conduct of University programs and activities at University owned or leased locations.

University departments may offer services only to other University departments and only for University-related work. Permitted work includes, instructional work for credit and non-credit courses, conferences, workshops, institutes, training programs, etc.; support for faculty research, publications, presentations, and outreach activities; services for recognized student organizations; and services for other organized student extramural activities.

University tangible assets and services may not be used for personal gain, by employees for purposes outside the scope of their employment (see also Policy HR35), or by students beyond their instructional requirements.

CROSS REFERENCES—Additional Policies to refer to would include:

RA10 - Handling Inquiries/Investigations into Questions of Ethics in Research and in Other Scholarly Activities,

IP02 - Coauthorship of Scholarly Reports, Papers and Publications (Formerly RA13),

HR35 - Public Service by Members of the Faculty and Staff,

HR91 - Conflict of Interest, and

RP03 - Use of Human Subjects in Research.

### **ADDRESSING ALLEGATIONS OF RESEARCH MISCONDUCT (FORMERLY HANDLING INQUIRIES/INVESTIGATIONS INTO QUESTIONS OF ETHICS IN RESEARCH AND IN OTHER SCHOLARLY ACTIVITIES)**

#### **PURPOSE:**

To establish policy and procedures to address allegations of research misconduct.

#### **PREAMBLE:**

Public trust in the integrity and ethical behavior of scholars is essential if research and other scholarly activities are to play their proper role in the University and in society. The maintenance of high ethical standards is a central and critical responsibility of faculty and administrators of academic institutions. Policy AD47 sets forth statements of general standards of professional ethics within the academic community.

#### **POLICY:**

Research misconduct is prohibited. Allegations of research misconduct shall be addressed in accordance with this policy and applicable regulations.

Faculty and staff members and students are required to comply with this policy and applicable regulations. Violation of this policy by a member of the faculty or staff, or a student, may subject the faculty or staff member or student to imposition of disciplinary sanctions, including, but not limited to, dismissal from employment or enrollment.

#### **DEFINITIONS:**

*Research Misconduct* is defined as fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results. It does not include honest error or differences of opinion.

*Fabrication* is defined as making up data or results and recording or reporting them.

*Falsification* is defined as manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.

*Plagiarism* is defined as the appropriation of another person's ideas, processes, results, or words without giving appropriate credit.

*Allegation* is defined as any oral or written disclosure of possible research misconduct made to an institutional official.

*Inquiry* is defined as information-gathering and preliminary fact-finding to determine whether an allegation or apparent instance of research misconduct warrants an investigation.

*Investigation* is defined as a formal examination and evaluation of relevant facts to determine whether research misconduct has taken place or, if research misconduct has already been confirmed, to assess its extent and consequences and determine appropriate action.

*Budget Executive* - Those individuals who are responsible to the President, Executive Vice President and Provost, or a Vice President for a section of the budget. These individuals are normally the President's administrative staff, academic Deans, and Chancellors. The budget executive approves transactions at the upper dollar levels and specified categories, affirming the programmatic need for the action and that the action is appropriate within University Policies and Guidelines.

*Budget Administrator* - Those individuals designated by the Budget Executive as being responsible for operating and controlling specific budget areas within the Budget Executive's administrative area. These individuals approve documents in their own name within the limits of the authorization policy stated below. This group normally includes associate deans, division heads, and department heads. The budget administrator approves transactions at the specified dollar levels and categories, affirming the programmatic need for the action and that the action is appropriate within University Policies and Guidelines.

*Research Integrity Officer* means the person appointed by the Vice President for Research to assume the responsibilities assigned to the Research Integrity Officer under this policy and applicable regulations.

#### GENERAL POLICY AND PRINCIPLES:

##### I. Responsibility to Report Possible Research Misconduct

Anyone having reason to believe that a member of the faculty, staff or student body has engaged in research misconduct has a responsibility to report pertinent facts in accordance with this policy. The person may discuss the situation with a Budget Administrator or Budget Executive or the Research Integrity Officer or may report the facts through other established reporting procedures, such as the University's ethics hotline. A Budget Administrator or Budget Executive who receives information about possible research misconduct shall inform the Research Integrity Officer. If the circumstances described do not meet the definition of research misconduct, the Research Integrity Officer may refer the individual or allegation to other offices or officials with responsibility for resolving the problem.

##### II. Confidentiality

The Research Integrity Officer shall endeavor to protect the confidentiality of respondents and complainants, and of research subjects identifiable from research records or evidence, by limiting disclosure to those who need to know in order to carry out a thorough, competent, objective, and fair research misconduct proceeding or as required by law.

##### III. Interim Administrative Actions and Notifying Federal Agencies of Special Circumstances

Throughout the research misconduct proceeding, the Research Integrity Officer will ensure that warranted interim actions are taken to protect public health, sponsor funds and equipment, and the integrity of the research process, and to ensure that the

purposes of the research activity and the financial assistance are carried out. Such actions may include, for example, additional monitoring of the research process and the handling of federal funds and equipment, reassignment of personnel or of responsibility for handling federal funds and equipment, additional review of research data and results, and delay in publication.

To the extent required by regulation or by the sponsor, the Research Integrity Officer shall, at any time during a research misconduct proceeding, notify appropriate federal or other officials of facts that may be relevant to protect public health, federal or other sponsor funds and equipment, and the integrity of the sponsor-supported research process and shall make other interim reports required by research sponsors.<sup>1</sup>

<sup>1</sup> Regulations applicable to research misconduct allegations under U.S. Public Health Service ("PHS") jurisdiction require immediate notification of the PHS Office of Research Integrity ("ORI") if the University has reason to believe that any of the following conditions exist: (1) health or safety of the public is at risk, including an immediate need to protect human or animal subjects; (2) U.S. Department of Health and Human Services ("HHS") resources or interests are threatened; (3) research activities should be suspended; (4) there is a reasonable indication of possible violations of civil or criminal law; (5) federal action is required to protect the interests of those involved in the research misconduct proceeding; (6) the University believes the research misconduct proceeding may be made public prematurely (so that HHS may take appropriate steps to safeguard evidence and protect the rights of those involved); or (7) the research community or public should be informed. 42 C.F.R. 93.318. Regulations applicable to research misconduct allegations under National Science Foundation ("NSF") jurisdiction require prompt notification of the NSF Office of Inspector General ("NSF OIG") should the University become aware during an Inquiry or Investigation that: (1) Public health or safety is at risk; (2) NSF's resources, reputation, or other interests need protecting; (3) There is reasonable indication of possible violations of civil or criminal law; (4) Research activities should be suspended; (5) Federal action may be needed to protect the interests of a subject of the Investigation or of others potentially affected; or (6) The scientific community or the public should be informed. 45 C.F.R. 689.4(c).

## PROCEDURE:

### I. Conducting the Inquiry

#### A. Assessment of Allegations

As soon as practicable after receiving an allegation of research misconduct, the Research Integrity Officer will assess the allegation to determine whether it (1) falls within the definition of research misconduct in this Policy and any applicable federal regulations, and (2) is sufficiently credible and specific so that potential evidence of research misconduct may be identified. If both of these criteria are met, an Inquiry will be conducted unless the Research Integrity Officer determines that unusual circumstances exist that make an inquiry infeasible or otherwise not warranted (such as that the conduct at issue is too old; see 42 CFR 93.105).

#### B. Notice to Respondent

At the time of or before beginning an Inquiry, the Research Integrity Officer shall make a good faith effort to notify the respondent in writing of the decision to conduct an Inquiry. If the Inquiry subsequently identifies additional respondents, they shall also be notified in writing.

#### C. Sequestration of the Research Records

On or before the date on which the respondent is notified, or the Inquiry begins, whichever is earlier, the Research Integrity Officer shall take all reasonable and practical steps to obtain custody of all the research records and evidence needed to conduct the research misconduct proceeding, inventory the records and evidence, and sequester them in a secure manner. Where the research records or evidence encompass scientific instruments

shared by a number of users, custody may be limited to copies of the data or evidence on such instruments, so long as those copies have evidentiary value substantially equivalent to that of the instruments.

D. Appointment of the Inquiry Committee

The Research Integrity Officer is responsible for conducting, or designating others to conduct, the Inquiry.<sup>2</sup> In cases where the allegations and apparent evidence are straightforward, the Research Integrity Officer may choose to conduct the Inquiry directly or designate another qualified individual, referred to as the inquiry official, to do so. The inquiry official shall not have unresolved personal, professional, or financial conflicts of interest in relation to the Inquiry and should have appropriate scientific expertise to evaluate the evidence and issues related to the allegation and conduct the Inquiry.

<sup>2</sup>Inquiry or Investigation that: (1) Public health or safety is at risk; (2) NSF's resources, reputation, or other interests need protecting; (3) There is reasonable indication of possible violations of civil or criminal law; (4) Research activities should be suspended; (5) Federal action may be needed to protect the interests of a subject of the Investigation or of others potentially affected; or (6) The scientific community or the public should be informed. 45 C.F.R. 689.4(c).

In complex cases, the Research Integrity Officer, in consultation with other University officials, as appropriate, will normally appoint a committee of three or more persons, including a committee chair, to conduct the Inquiry. Where warranted, the Research Integrity Officer may determine that a smaller or larger committee is appropriate. The members of the inquiry committee shall consist of individuals who do not have unresolved personal, professional, or financial conflicts of interest in relation to the Inquiry and should include individuals with the appropriate scientific expertise to evaluate the evidence and issues related to the allegation and conduct the Inquiry. When necessary to secure expertise or to avoid conflicts of interest, the Research Integrity Officer may select committee members from outside the University.

The Research Integrity Officer, in consultation with the inquiry committee, will determine whether additional experts are needed to provide special expertise to the inquiry committee regarding the analysis of specific evidence. If experts are utilized, their role will be advisory to the inquiry committee.

The respondent shall have an opportunity to object to the inquiry official or a proposed member of the inquiry committee based upon a personal, professional, or financial conflict of interest, by submitting written objections to the Research Integrity Officer no more than 10 days following notification of the proposed inquiry official or committee membership. The Research Integrity Officer makes the final determination as to whether a conflict exists.

E. Charge to the Inquiry Committee

The Research Integrity Officer will prepare a charge to the inquiry official or inquiry committee that: (1) sets forth the time for completion of the Inquiry; (2) describes the allegations and any related issues identified during the allegation assessment; (3) states that the purpose of the Inquiry is to conduct an initial review of the evidence to determine whether an Investigation is warranted, not to determine whether research misconduct definitely occurred or who was responsible; (4) states the criteria for determining that an Investigation is warranted; and (5) states that the inquiry official or inquiry committee is responsible for preparing or directing the preparation of a written report of the Inquiry that meets the requirements of Section V of this Policy.

The Research Integrity Officer may choose to meet with the inquiry official or inquiry committee to review the charge, discuss the allegations, discuss the appropriate procedures for conducting the Inquiry, assist the inquiry official or committee with organizing plans for the Inquiry, and answer any questions raised by the inquiry official or committee.

The Research Integrity Officer or his or her designee will be available throughout the Inquiry to advise the inquiry official or inquiry committee as needed.

F. Inquiry Process

The purpose of the Inquiry is to conduct an initial review of the available evidence to determine whether to conduct an Investigation. The purpose of the Inquiry is not to decide whether research misconduct definitely occurred, determine who committed the research misconduct or conduct exhaustive interviews and analysis. If interviews are conducted as part of the Inquiry, each interview shall be recorded or transcribed, and the recording or transcript shall be provided to the interviewee for correction and shall be included, with any written corrections, in the record of the Inquiry.

After evaluation of the evidence, the inquiry official or inquiry committee will consult with the Research Integrity Officer and decide whether to recommend that an Investigation is warranted. An Investigation is warranted if: (1) there is a reasonable basis for concluding that the allegation falls within the definition of research misconduct in this Policy and (2) preliminary information-gathering and preliminary fact-finding from the Inquiry indicate that the allegation may have substance.

If the respondent admits research misconduct, a determination of misconduct may be made at or before the Inquiry stage if all relevant issues are resolved. In that case, the Research Integrity Officer, in consultation with the Vice President for Research and other appropriate University officials, shall promptly consult with any appropriate federal agencies to determine the next steps that should be taken.

G. Time for Completion

The Inquiry, including preparation of the final inquiry report and the decision of the Vice President for Research on whether an Investigation is warranted, must be completed within 60 days of its initiation unless the Research Integrity Officer determines that circumstances warrant a longer period. If the Inquiry takes longer than 60 days, and the Research Integrity Officer approves an extension, the Inquiry record shall include documentation of the reasons for exceeding the 60-day period.

II. The Inquiry Report

A. Elements of the Inquiry Report

A written inquiry report shall be prepared that includes the following information: (1) the name and position of the respondent; (2) a description of the allegations of research misconduct; (3) pertinent federal agency support, including, for example, grant numbers, grant applications, contracts, and publications listing such support; (4) the basis for recommending or not recommending that the allegations warrant an Investigation; and (5) any written comments on the draft report by the respondent or the complainant.

The inquiry report should also include: the names and titles of the inquiry official or committee members and experts who conducted the Inquiry; a summary of the inquiry process used; a list of the research records reviewed; and whether any other actions should be taken if an Investigation is not recommended. The inquiry report shall either be signed by the inquiry official or by each member of the inquiry committee or shall include other written evidence of each person's concurrence or non-concurrence with the findings and conclusions of the Inquiry.

B. Opportunity to Comment on the Inquiry Report

The Research Integrity Officer shall provide the respondent with a copy of the draft inquiry report and, concurrently, with a copy of any applicable federal research misconduct policy. The respondent shall be provided with an opportunity to review and comment on the inquiry report. Any comments from the respondent must be in writing and received within 10 days of his/her receipt of the inquiry report and will be attached to the report. Based on the comments, the inquiry committee may revise the draft report as appropriate and prepare it in final form. The Research Integrity Officer will deliver the final report to the Vice President for Research.

The Research Integrity Officer may provide the complainant with relevant portions of the inquiry report for comment. Any comments from the complainant must be in writing and received within 10 days of his/her receipt of the inquiry report.

C. Decision and Notification

1. Decision by the Vice President for Research

The Research Integrity Officer will transmit the final inquiry report and any written comments to the Vice President for Research, who will determine in writing whether an Investigation is warranted. The Inquiry is complete when the Vice President for Research makes this determination.

2. Notice to Respondent and Complainant

The Research Integrity Officer shall notify the respondent whether the Inquiry found that an Investigation is warranted. The notice shall include a copy of the inquiry report and include a copy of or refer to this Policy and any applicable federal research misconduct policy.

3. Notice to Applicable Sponsor or Federal Agency

The Research Integrity Officer shall provide to applicable sponsors or federal agencies any required reports regarding the Inquiry and decision to initiate an Investigation. For cases involving ORI jurisdiction, within 30 days of the Vice President for Research's decision that an Investigation is warranted, but not later than the date the Investigation begins, the Research Integrity Officer shall provide ORI with the Vice President for Research's written decision and a copy of the inquiry report. The Research Integrity Officer will also notify University officials who need to know of the Vice President for Research's decision.

4. Documentation of Decision Not to Investigate

If the Vice President for Research decides that an Investigation is not warranted, the Research Integrity Officer shall secure and maintain, for seven years after the termination of the Inquiry, sufficiently detailed documentation of the Inquiry to permit a later assessment by supporting federal agencies of the reasons why an Investigation was not conducted. These documents shall be provided to authorized federal personnel upon request.

### III. Conducting the Investigation

#### A. Initiation and Purpose

The Investigation shall begin within 30 days after the Vice President for Research's determination that an Investigation is warranted. The purpose of the Investigation is to develop a factual record by exploring the allegations in detail and examining the evidence in depth, leading to findings on whether research misconduct has been committed, by whom, and to what extent. The Investigation will also determine whether there are additional instances of possible research misconduct that would justify broadening the scope beyond the initial allegations. The findings of the Investigation shall be set forth in an investigation report.

#### B. Notice to Respondent

Within a reasonable time after determining that an Investigation is warranted, but before the Investigation begins, the Research Integrity Officer shall notify the respondent in writing of the allegations to be investigated. If allegations not addressed during the Inquiry or in the initial notice of the Investigation are pursued, the Research Integrity Officer shall give the respondent written notice of any such new allegations.

#### C. Sequestration of the Research Records

Before or at the time the University notifies the respondent of the Investigation, the Research Integrity Officer shall take all reasonable and practical steps to obtain custody of and sequester in a secure manner all research records and evidence needed to conduct the research misconduct proceeding that were not previously sequestered during the Inquiry. Where the research records or evidence encompass scientific instruments shared by a number of users, custody may be limited to copies of the data or evidence on such instruments, so long as those copies are substantially equivalent, in evidentiary value, to the instruments. If additional items become known or relevant during the Investigation, the Research Integrity Officer shall take reasonable and practical steps to obtain custody of those records.

#### D. Appointment of the Investigation Committee

As soon as practicable after the Vice President for Research determines that an investigation is warranted, the Research Integrity Officer, in consultation with other University officials, as appropriate, will appoint an investigation committee and committee chair, which will conduct the Investigation.

The investigation committee shall consist of individuals who did not serve on the inquiry committee and who do not have unresolved personal, professional, or financial conflicts of interest in relation to the Investigation. Investigation committee members should have appropriate scientific expertise to evaluate the evidence and issues related to the allegation, interview the respondent and complainant, and conduct the Investigation. When necessary to secure expertise or to avoid conflicts of interest, the Research Integrity Officer may select committee members from outside the University. The Research Integrity Officer may not serve as a member of the investigation committee.

The respondent shall have an opportunity to object to proposed members of the investigation committee based upon personal, professional or financial conflict of interest, by submitting written objections to the Research Integrity Officer no more than 10 days following notification regarding the committee membership. The Research Integrity Officer makes the final determination as to whether a conflict exists.

E. Charge to the Investigation Committee

The Research Integrity Officer will define the subject matter of the Investigation in a written charge to the investigation committee that: (1) describes the allegations and related issues identified during the Inquiry; (2) identifies the respondent; (3) informs the investigation committee that it must conduct the Investigation as prescribed in this Policy; (4) defines research misconduct; (5) informs the investigation committee that it must evaluate the evidence and testimony to determine whether, based on a preponderance of the evidence, research misconduct occurred and, if so, the type and extent and who was responsible; and (6) informs the investigation committee that it must prepare or direct the preparation of a written investigation report that meets the requirements of Section VII.A.

The Research Integrity Officer may choose to meet with the investigation committee to review the charge, the inquiry report, and prescribed procedures and standards for the conduct of the Investigation, including the necessity for confidentiality and for developing a specific Investigation plan.

The investigation committee shall be provided with a copy of this Policy and any applicable federal research misconduct policy. The Research Integrity Officer or designee will ordinarily be available throughout the Investigation to advise the investigation committee as needed.

F. Investigation Process

The investigation committee and the Research Integrity Officer shall:

1. Use diligent efforts to ensure that the Investigation is thorough and sufficiently documented and includes examination of all research records and evidence relevant to reaching a decision on the merits of each allegation;
2. Take reasonable steps to ensure an impartial and unbiased Investigation to the maximum extent practical, including participation of persons with appropriate scientific expertise who do not have unresolved personal, professional, or financial conflicts of interest with those involved with the Inquiry or Investigation;
3. Interview each respondent, complainant, and any other available person who has been reasonably identified as having information regarding any relevant aspects of the Investigation, including witnesses identified by the respondent, and record and transcribe each interview, provide the recording or transcript to the interviewee for correction, and include the recording or transcript, and any written corrections, in the record of the Investigation; and
4. Pursue diligently all significant issues and leads discovered that are determined relevant to the Investigation, including any evidence of additional instances of possible research misconduct, and continue the Investigation to completion.

G. Standard for Making a Finding of Research Misconduct



In order to make a finding of research misconduct, the investigation committee must find by a preponderance of the evidence that: (1) research misconduct occurred, as defined in this Policy or applicable federal agency policy; (2) the research misconduct is a significant departure from accepted practices of the relevant research community; and (3) the respondent committed the research misconduct intentionally, knowingly, or recklessly.

The Research Integrity Officer will advise the investigation committee of any additional applicable regulatory standards for making a finding of research misconduct. (*See, for example*, 42 CFR 93.106.)

#### H. Time for Completion

The Investigation shall ordinarily be completed within 120 days of its initiation, including conducting the Investigation, preparing the report of findings, providing the draft report for comment, and sending the final report to any applicable federal agency. However, if the Research Integrity Officer determines that the Investigation will not be completed within the 120-day period, or as requested by the applicable agency, he/she shall submit to the applicable agency, or if no agency is involved, to the Vice President for Research, a written request for an extension setting forth the reasons for the delay.

### IV. The Investigation Report

#### A. Elements of the Investigation Report

The investigation committee and the Research Integrity Officer are responsible for preparing a written investigation report which shall: (1) describe the nature of the allegation of research misconduct; (2) describe and document any federal or private funding, including, for example, any grant numbers, grant applications, contracts, and publications listing any such support; (3) describe the specific allegations of research misconduct considered in the Investigation; (4) include a copy of this Policy; and (5) identify and summarize the research records and evidence reviewed and identify any evidence taken into custody but not reviewed.

The report shall also include a statement of findings for each separate allegation of research misconduct identified during the Investigation. Each statement of findings shall provide a decision as to whether misconduct did or did not occur, and if so --

(1) Identify whether the research misconduct was:

- a. falsification, fabrication, or plagiarism,
- b. a significant departure from accepted practices of the relevant research community, and
- c. committed intentionally, knowingly, or recklessly;

(2) Summarize the facts and the analysis that support the conclusion and consider the merits of any reasonable explanation by the respondent;

(3) Identify specifically any pertinent federal support or proposals (reports to ORI shall include current support from, and known applications or proposals for support to, PHS as well as other federal agencies);

(4) Identify whether publications need correction or retraction; and

(5) Identify the person(s) responsible for the misconduct.

The investigation report shall either be signed by each member of the investigation committee or shall include other written evidence of each member's concurrence or non-concurrence with the findings and conclusions of the Investigation.

B. Comments on the Draft Investigation Report and Access to Evidence

1. Respondent

The Research Integrity Officer shall provide the respondent with a copy of the draft investigation report for comment, and shall provide the respondent, concurrently, with a copy of, or supervised access to, the evidence on which the report is based. The respondent shall be allowed 30 days to review the draft report and submit written comments to the Research Integrity Officer. The respondent's comments shall be taken into consideration when preparing the final investigation report and shall be attached to the final report.

2. Complainant

The Research Integrity Officer may provide the complainant with a copy of the draft investigation report, or relevant portions of it, for comment. If provided with a copy of the report, the complainant's comments must be in writing and submitted within 30 days of the date on which he/she received the draft report. Comments received from the complainant shall be taken into consideration in preparing the final investigation report and shall be attached to the final report.

3. Confidentiality

In distributing the draft report, or portions thereof, to the respondent or complainant, the Research Integrity Officer will inform the recipient of the confidentiality under which the draft report is made available and may establish reasonable conditions to ensure such confidentiality. For example, the Research Integrity Officer may require that the recipient sign a confidentiality agreement.

C. Decision by the Vice President for Research

The Research Integrity Officer will assist the investigation committee in finalizing the draft investigation report, including ensuring that the respondent's and, in appropriate cases, the complainant's written comments are included and considered. The Research Integrity Officer will transmit the final investigation report to the Vice President for Research, who will determine in writing: (1) whether the University accepts the Investigation's findings; and (2) the appropriate internal actions to be taken or recommended in response to the accepted findings of research misconduct. If the Vice President for Research's determination varies from the findings of the investigation committee, the Vice President for Research will, as part of his/her written determination, explain in detail the basis for rendering a decision different from the findings of the investigation committee. Alternatively, the Vice President for Research may return the report to the investigation committee with a request for further fact-finding or analysis.

When a final decision on the case has been reached, the Research Integrity Officer will normally notify both the respondent and the complainant in writing. The Research Integrity Officer is also responsible for ensuring compliance with all notification requirements of funding or sponsoring agencies. The Vice President for Research in consultation as appropriate with the Research Integrity Officer and other University officials will determine whether law enforcement agencies, professional societies, professional licensing boards, editors of journals in which falsified

reports may have been published, collaborators of the respondent in the work, or other relevant parties should be notified of the outcome of the case.

#### D. Notice to Applicable Federal Agencies of University Findings and Actions

Unless an extension has been granted, within 120 days of beginning the Investigation, the Research Integrity Officer shall submit to any applicable federal agency a copy of the final investigation report with attachments; a statement of whether the University accepts the findings of the investigation report; a statement of whether the University found research misconduct and, if so, who committed the misconduct; and, if required by the agency, a description of any pending or completed administrative actions against the respondent.

#### E. Maintaining Records for Review by Federal Agencies

The Research Integrity Officer shall maintain, and upon request, provide to authorized federal officials, records of the research misconduct proceedings, including: (1) records secured by the University for the Inquiry and Investigation; (2) documentation of the determination of irrelevant or duplicate records; (3) the inquiry report and final documents produced in the course of preparing that report, including the documentation of any decision not to investigate; and (4) the investigation report and the records in support of that report, including the recording or transcript of each interview conducted pursuant to this Policy.

Unless custody has been transferred to the applicable federal agency or the agency has advised the University, in writing, that the records no longer need to be retained, these records shall be maintained in a secure manner for seven years after the later of completion of the proceeding or the completion of any federal agency proceeding involving the research misconduct allegation.

The Research Integrity Officer is also responsible for providing any information, documentation, research records, evidence, or clarification requested by authorized federal officials to carry out their review of an allegation of research misconduct or of the University's handling of such an allegation.

#### V. Completion of Cases and Reporting Premature Closures to Applicable Federal Agencies

Generally, all Inquiries and Investigations will be carried through to completion and all significant issues will be pursued diligently. The Research Integrity Officer shall, if required by such agency, notify any applicable federal agency in advance if there are plans to close a case at the Inquiry or Investigation stage on the basis that the respondent has admitted guilt, a settlement with the respondent has been reached, or for any other reason except that: (1) no notification to federal agencies need be provided when a case is closed after an Inquiry that finds pursuant to Section IV.F that an Investigation is not warranted; and (2) if an Investigation is completed, the University's findings must be reported as specified under Section VII.D of this Policy.

#### VI. Internal Administrative Actions

If the Vice President for Research determines that a finding of research misconduct is substantiated, the University, through the Vice President for Research, the Budget Executive, the Budget Administrator or other appropriate official, may adopt sanctions, which may include, for example:

- a. Re-training;
- b. Unannounced or announced audits;
- c. A letter of reprimand or admonishment to be included in respondent's file;

- d. Supervision or monitoring of future work, including a requirement for certification by senior personnel that a person's work met specified conditions;
- e. Removal from the research project in question;
- f. Formal notification of sponsoring agencies, funding sources, co-authors, co-investigators, collaborators or journal editors;
- g. Withdrawal or correction of pending abstracts and papers emanating from the research where research misconduct was found;
- h. Formal withdrawal of pending applications for research support;
- i. Public announcements; and/or
- j. Restitution of funds.

If the Vice President for Research determines that a finding of research misconduct is substantiated, the Vice President for Research may also recommend to the Budget Executive or other appropriate University official, disciplinary sanctions, which may include, for example:

- a. Probation or suspension;
- b. Initiation of steps leading to possible impact on salary; and/or
- c. Initiation of steps leading to possible termination of employment.

None of these sanctions limits the authority of the funding sponsor to impose its own sanctions.

## VII. Other Considerations

### A. Protecting the Respondent

Respondents may consult with legal counsel or a non-lawyer personal adviser (who is not a principal or witness in the case) to seek advice. During research misconduct proceedings, the respondent may be accompanied by counsel or a personal adviser at interviews and meetings, but the lawyer or personal adviser's role will be limited to counseling the respondent, and the respondent will be responsible for answering all questions.

As requested and appropriate, the Research Integrity Officer and other University officials shall make all reasonable and practical efforts to protect or restore the reputation of persons alleged to have engaged in research misconduct but against whom no finding of research misconduct is made. Depending on the particular circumstances and the views of the respondent, the Research Integrity Officer should consider whether to notify those individuals aware of or involved in the research misconduct proceeding of the final outcome, publicize the final outcome in any forum in which the allegation of research misconduct was previously publicized, and/or expunge references to the research misconduct allegation from the respondent's personnel file.

### B. Protecting the Complainant, Witnesses and Committee Members

University faculty, staff, and students may not retaliate in any way against complainants, witnesses, or committee members. Faculty, staff, and students should immediately report any alleged or apparent retaliation against complainants, witnesses, or committee members to the Research Integrity Officer.

During the research misconduct proceeding and upon its completion, regardless of whether or not the University or a federal agency determines that research misconduct occurred, the Research Integrity Officer shall undertake all reasonable and practical efforts to protect the position and reputation of, or to counter potential or actual retaliation against, any complainant who made allegations of research misconduct in good faith and of any witnesses and committee members who cooperate in good faith with the research misconduct proceeding.

### C. Allegations Not Made in Good Faith

If relevant, the Vice President for Research will determine whether the complainant's allegations of research misconduct were made in good faith, or whether a witness or committee member acted in good faith. If the Vice President for Research determines that the complainant knowingly made a false allegation of research misconduct, the Vice President for Research shall determine whether any administrative action will be taken against the complainant or whether any disciplinary action against the complainant will be recommended to the Budget Executive or other appropriate University official.

CROSS-REFERENCES—Other Policies in this Manual should also be referenced, especially the following:

IP01 Ownership and Management of Intellectual Property  
IP06 Technology Transfer and Entrepreneurial Activity (Faculty Research)  
RP03 The Use of Human Subjects in Research

## **CO-AUTHORSHIP OF SCHOLARLY REPORTS, PAPERS AND PUBLICATIONS (Formerly Policy RA13)**

### PURPOSE:

It is the policy of The Pennsylvania State University that proper credit be given to those individuals who make material contributions to activities which lead to scholarly reports, papers and publications.

### GUIDELINES:

Rigid prescriptive requirements in this area are considered unwise, because the situation with respect to co-authorship varies from one discipline to another and from one publication to another. Nevertheless, it is recommended that the authors of scholarly reports, papers and publications abide by the following principles regarding co-authorship.

- (1) Co-authorship should be offered to anyone who has clearly made a material contribution to the work.  
Moreover, each coauthor should be furnished with a copy of the manuscript before it is submitted, and allowed an opportunity to review it prior to submission. An author submitting a paper, report or publication should never include the name of a coauthor without the person's consent. Exceptional circumstances, such as death or inability to locate a coauthor, should be handled on a case by case basis. In cases where the contribution may have been marginal, an acknowledgment of the contribution in the public action might be more appropriate than co-authorship.
- (2) In cases of theses for advanced degrees, if any publication derived from the thesis is not published with the degree recipient as sole author, then that person should be listed as coauthor. In no instance should publications derived from a thesis be published under the sole authorship of the thesis adviser.
- (3) Anyone accepting co-authorship of a paper must realize that this action implies a responsibility as well as a privilege. As a general rule, each coauthor should understand the content of the publication well enough to be able to take responsibility for all of it; otherwise, the publication should clearly indicate the parts of which each coauthor has responsibility. If a potential coauthor has doubts concerning the correctness of the content or conclusions of a publication, and if these doubts cannot be dispelled by consultation with the other coauthors, the individual should decline co-authorship.

## GRADUATE ASSISTANTS

### PURPOSE:

To state the Graduate Assistant Policy of the University.

### TYPES AND SALARY RANGES:

Graduate assistantships are of three types: quarter-time, half-time, and three-quarter-time. The expected duration of assigned tasks is the same for all graduate assistants within the same type. Thus, for all quarter-time graduate assistants, irrespective of stipend, 10 hours of regular work per week are expected; for all half-time assistants, 20 hours; and for all three-quarter-time assistants, 30 hours. A semester normally consists of 18 full weeks, and extended summer session 14 weeks. Appointments are to be made at one of several grades in consideration of experience and qualifications of the individual. Refer to the Table of Stipends for Graduate Assistants and the Penn State Graduate Degree Programs Bulletin for further information.

Within any department or other administrative unit of the University, there shall be the same pay for the same work for graduate assistants regardless of the field of study in which the student is enrolled. This policy shall not preclude a scale of stipends based on merit, seniority or degree candidacy.

### ELIGIBILITY:

Graduate assistants must be enrolled at Penn State as graduate students. More specifically, since assistantships are provided as aids to completion of advanced degrees, assistants are expected to enroll for credit loads each semester that fall within the limits indicated in the table below. Maximum limits on permissible credit loads are indicated in order to assure that the student can give appropriate attention both to academic progress and assistantship responsibilities. These considerations give rise to the table of permissible credit loads below.

### OFFER OF APPOINTMENT:

Every Graduate Assistant shall be offered his or her appointment each year in writing, using a standard form, the *Terms of Offer of a Graduate Assistantship*, together with an individual letter of transmittal. The letter will indicate any extensive duties other than professional and preprofessional they will be called upon to perform.

### RESPONSIBILITIES:

A graduate assistant may assist in classroom or laboratory instruction, in research or in other work. The tasks assigned to a graduate assistant often are identical in nature to those required for the advanced degree sought. If the duties are identical in nature to those required for the advanced degree sought, it must be noted in the Terms of Offer of a Graduate Assistantship, the individual letter of transmittal and on the appropriate IBIS appointment, reappointment or change form. Additional compensation is paid to a graduate assistant by the University for additional hours of work only with special, advance approval of the administrative head of the academic unit in which the assistantship is held, and of the chair of the student's graduate academic program, and provided that such compensation is not for additional hours of work on the assigned assistantship duties.

### LENGTH OF APPOINTMENTS:

The appointment may be for the summer session or one or two semesters and must terminate on or before the end of the spring semester in any fiscal year. When an appointment will terminate before the end of the spring semester, the appointee should be informed of this when offered the assistantship.

## HEALTH INSURANCE BENEFIT:

International Graduate Assistants are required to have health insurance coverage for themselves and their dependents in the United States. For domestic Graduate Assistants, health insurance is optional. The University provides a health insurance benefit as part of the assistantship contract. The University will pay a percentage of the annual premium for the Penn State Student Health Insurance Plan. The remaining percentage will be automatically deducted from the student's assistantship stipend. The University will not supplement, nor will a payroll deduction be made, for insurance policies other than the Penn State Student Insurance Plan.

International Graduate Assistants who have adequate alternate medical coverage and who do not wish to be enrolled in the Penn State Student Health Insurance Plan must submit a waiver application. In order to be granted a waiver, alternate plans must meet certain standards as established by the University Student Insurance Committee. This Committee will approve or disapprove the waiver application.

International Graduate Assistants who do not apply for a waiver will be automatically enrolled in the Penn State Student Insurance Plan.

(NOTE: *Applications for a waiver demonstrating adequate alternate insurance must be submitted on a yearly basis each fall.*)

Domestic Graduate Assistants will automatically be enrolled in the Penn State Student Insurance Plan. Domestic Graduate Assistants who do not wish to be enrolled in the Penn State Student Insurance Plan must decline the insurance. Dependent health insurance coverage for domestic Graduate Assistants must be submitted on a yearly basis each fall.

For further information, contact the Student Insurance Office, 814-865-7467, or see "Graduate Assistant and Graduate Fellow Health Insurance Plan" on the University Health Services website.

## FORMS TO BE COMPLETED BY AND FOR GRADUATE ASSISTANTS:

A graduate assistant is appointed by completing an "NAPP/GFSA" in IBIS. Each appointment is approved, based upon the budget administrator's recommendation and certification of eligibility by the Dean of the Graduate School.

According to Policy HR30, the budget executive is responsible for providing proof that there are no subversive persons employed in his/her area of responsibility.

In accepting an appointment as a graduate assistant, the recipient is required to complete the following forms:

1. Employee's Withholding Allowance Certificate - Form W-4. Also, see Policy [PR13](#).
2. Employment Eligibility Verification (INS Form I-9).
3. University Intellectual Property Agreements.
4. Salary Deposit Request.

## SUBMISSION OF FORMS FOR THE APPOINTMENT OF GRADUATE ASSISTANTS:

The *Employee's Withholding Allowance Certificate (W-4)* and *Salary Deposit Requests* are attached and submitted together to the Financial Officer. The forms are required in the Payroll Office **one month before** the first pay date each semester/session. The "GFSA" is approved and processed electronically.

Appointments are to be submitted in accordance with stipends authorized in the Table of Stipends for Graduate Assistants.

## SUBMISSION OF FORMS FOR THE REAPPOINTMENT OF GRADUATE ASSISTANTS:

The "GRAD" is submitted with the block "Reappointment" marked. It is not required that a new *Employee's Withholding Allowance Certificate (W-4)* be completed if the graduate assistant's status (i.e., number of withholding exemptions, local earned income tax,

address and/or name) is unchanged, providing that the graduate assistant's original appointment has not been terminated for more than a year.

#### CREDITS THAT MAY BE SCHEDULED:

The privileges of graduate study are the same for all graduate assistants within the same type. The table that follows shows the number of credits that normally may be scheduled for **each** semester or session.

|   | Fall/Spring | Summer |
|---|-------------|--------|
| Graduate Assistant - Quarter-Time       | 9-14        | 5-7    |
| Graduate Assistant - Half-Time          | 9-12        | 4-6    |
| Graduate Assistant - Three-Quarter-Time | 6-8         | 3-4    |

The credits specified are the number which the appointee is ordinarily expected to carry. To provide some flexibility, moderate exceptions to the specified limits may be made in particular cases. The credit limits specified above may only be increased or decreased in exceptional cases for a specific semester or summer session by permission of the assistantship supervisor, the student's academic adviser, and the dean of the Graduate School (requests should be submitted for the dean's approval via the Office of Graduate Enrollment Services). It is expected that:

- The credit load and the service load are properly balanced in each semester and the total credit load over a period of time conforms with the specified limits.
- The total number of credits scheduled during the interval of appointment is consistent with the type of appointment.
- The student is assigned no more than the normal work load during the first semester/session as a graduate student at the University, thus permitting him or her to be primarily a student during this period.

#### EVALUATION AND PERFORMANCE:

Each graduate assistant shall be supervised and assisted in assigned tasks until they gain experience and skill enabling them to take responsibility. Each graduate assistant shall have his or her work evaluated at least once each year, and the supervisor shall discuss with the individual how well he/she performed during the appointment period.

#### PAYMENT OF STIPENDS:

All graduate assistant appointees are paid monthly. Direct salary deposits shall be mandatory and a condition of hire.



#### RATES CHARGED TO FUNDING SOURCES:

Graduate Assistant tuition will be charged to sponsored agreements at an average in-state rate.

Flat rate dissertation fees will be charged to a sponsored agreements for assistantships.

Tuition coverage through the Tuition Assistance Program is not available during any period for which the student is appointed on an assistantship.

#### CHANGES:

All changes to the appointment are accomplished by submitting an IBIS "*GRAD*."

#### TERMINATION:

All graduate assistant appointments are terminated automatically upon expiration without submitting termination forms; however, early terminations must be made by submitting an IBIS "*TRMN/GFST*."

The amount of final pay for an early termination is to be determined by subtracting the amount of stipend paid to the graduate assistant from the number of weeks of service rendered to the date of termination. If additional days are involved, the daily rate of 1/7th of the weekly rate applies.

# APPENDIX II

**MASTER OF SCIENCE IN COMPUTER SCIENCE & ENGINEERING  
DEGREE CHECKSHEET**

Student's Name: \_\_\_\_\_

PSU ID: \_\_\_\_\_

Background – only three credits of background courses can be used to satisfy graduate degree.

- \_\_\_\_\_ CMPSC 473
- \_\_\_\_\_ CMPEN 431
- \_\_\_\_\_ CMPSC 461
- \_\_\_\_\_ CMPSC 465
- \_\_\_\_\_ CMPEN 471 or CMPSC 464

15 credits – 500 level courses (including 9 credits of breadth courses)

- \_\_\_\_\_ \_\_\_\_\_
- \_\_\_\_\_ \_\_\_\_\_
- \_\_\_\_\_ \_\_\_\_\_

Breadth Areas:      A\_\_ B\_\_ C\_\_ D\_\_ E\_\_

9 credits – 400 level and above excluding Individual Studies & ENGR 588

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

CSE 590 \_\_\_\_\_ semester \_\_\_\_\_

CSE 600 \_\_\_\_\_ cr.      \_\_\_\_\_ cr.

\_\_\_\_\_ SARI Requirement

\_\_\_\_\_ Student has completed ALL requirements for graduation.

\_\_\_\_\_ Student will meet all of the requirements for graduation upon successful completion of the following:

Graduate Officer's  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**MASTER OF ENGINEERING IN COMPUTER SCIENCE & ENGINEERING DEGREE  
CHECKSHEET (1 YR M ENG)**

Student's Name: \_\_\_\_\_

PSU ID: \_\_\_\_\_

12 credits – Fall Semester

\_\_\_\_\_ CmpSc 465 (3) Options 1 and 2

\_\_\_\_\_ CSE 5xx elective (3)

\_\_\_\_\_ CmpSc 443 (3) or CSE 543 (3) **AND** \_\_\_\_\_ CmpSc 431 (3) Option 1

**OR**

\_\_\_\_\_ CmpEn 431 (3) **AND** \_\_\_\_\_ CmpEn 472 (3) Option 2

12 credits – Spring Semester (Options 1 and 2)

\_\_\_\_\_ CSE 5xx elective (3)

\_\_\_\_\_ CSE 5xx elective (3)

\_\_\_\_\_ CSE 5xx elective (3)

\_\_\_\_\_ CSE 5xx elective (3)

6 credits – Summer Semester

\_\_\_\_\_ CSE 820 (3)

\_\_\_\_\_ CSE 594 (3)

A grade of C or higher must be earned for each course. Student must maintain cumulative gpa of 3.00 or higher for graduation.

\_\_\_\_\_ SARI Requirement (5 hours of seminar attendance and on-line CITI training)

\_\_\_\_\_ Student has completed ALL requirements for graduation.

\_\_\_\_\_ Student will meet all of the requirements for graduation upon successful completion of the following:

Graduate Officer's  
Signature: \_\_\_\_\_

Date: \_\_\_\_\_

## DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE & ENGINEERING DEGREE CHECKSHEET (old requirements – Prior to Fall 2017)

Student's Name: \_\_\_\_\_

PSU ID: \_\_\_\_\_

48 credits of non-thesis credit:

27 credits – 500-589 or CSE 598 prior to FA2013 or CSE 597 beginning FA2013

\_\_\_\_\_  
\_\_\_\_\_

21 credits – 400 level and above

Breadth Requirement Met

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Req. 1 \_\_\_\_\_  
Req. 2 \_\_\_\_\_  
Req. 3 \_\_\_\_\_  
Req. 4 \_\_\_\_\_

590 (Colloquium) – 3 credits

\_\_\_\_\_  
\_\_\_\_\_

CSE 591 – Ph.D. Candidacy

Candidacy Areas Passed

\_\_\_\_\_

Dept. Engl Proficiency Exam

\_\_\_\_\_

\_\_\_\_\_

AEOCPT (International Students only)

\_\_\_\_\_

\_\_\_\_\_

Comprehensive Exam

\_\_\_\_\_

Dissertation Exam

\_\_\_\_\_

SARI Requirement

\_\_\_\_\_

Additional Comments:

Notes:

- A maximum of 3 credits of X96 may also be counted.
- At most, 3 credits of background course work can be used to satisfy the degree requirement.

Graduate Officer's

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE & ENGINEERING DEGREE CHECKSHEET (new requirements effective Fall 2017)**

Student's Name: \_\_\_\_\_

PSU ID: \_\_\_\_\_

**Students who do not have an MS in Computer Science or Computer Engineering must take a minimum of 33 credits**

**6 credits**

CSE 565            CSE 511            CSE 530  
\_\_\_\_\_  
\_\_\_\_\_

**15 credits** – CSE courses (excluding 598, 596)  
597 courses can be counted towards the 15 credits)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Breadth Requirement Met  
Req. 1 \_  
Req. 2 \_  
Req. 3 \_  
Req. 4 \_

**9 credits** – 400/500/800 level courses in CSE/EE/Math/  
STAT or 500/800 level courses in IST (a maximum of 3 credits  
of CSE 596 can be counted towards the 9 credits)

\_\_\_\_\_  
\_\_\_\_\_

590 (Colloquium) – **2 credits**

\_\_\_\_\_  
\_\_\_\_\_

CSE 591 – Ph.D. Candidacy- **1 credit**

Candidacy Areas Passed

\_\_\_\_\_  
\_\_\_\_\_

Dept. Engl Proficiency Exam \_\_\_\_\_

\_\_\_\_\_  
AEOCPT (International Students only) \_\_\_\_\_

\_\_\_\_\_  
Comprehensive Exam

\_\_\_\_\_  
Dissertation Exam

\_\_\_\_\_  
SARI Requirement

\_\_\_\_\_  
Additional Comments:

Graduate Officer's  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE & ENGINEERING DEGREE CHECKSHEET (new requirements effective Fall 2017)**

Student's Name: \_\_\_\_\_

PSU ID: \_\_\_\_\_

**Students who have an MS in Computer Science or Computer Engineering must take a minimum of 21 credits**

**6 credits**

CSE 565            CSE 511            CSE 530  
\_\_\_\_\_  
\_\_\_\_\_

**9 credits** – CSE courses (excluding 598, 596)  
597 courses can be counted towards the 9 credits)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Breadth Requirement Met  
Req. 1 \_  
Req. 2 \_  
Req. 3 \_  
Req. 4 \_

**3 credits** – 400/500/800 level courses in CSE/EE/Math/  
STAT or 500/800 level courses in IST (a maximum of 3 credits  
of CSE 596 can be counted towards the 3 credits)

\_\_\_\_\_  
\_\_\_\_\_

590 (Colloquium) – **2 credits**

\_\_\_\_\_  
\_\_\_\_\_

CSE 591 – Ph.D. Candidacy - **1 credit**

Candidacy Areas Passed

\_\_\_\_\_  
\_\_\_\_\_

Dept. Engl Proficiency Exam  
\_\_\_\_\_

AEOCPT (International Students only)  
\_\_\_\_\_

Comprehensive Exam  
\_\_\_\_\_

Dissertation Exam  
\_\_\_\_\_

SARI Requirement  
\_\_\_\_\_

Additional Comments:

Graduate Officer's  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_