Handbook for Graduate Students*

Department of Computational Mathematics, Science and Engineering

Michigan State University

CMSE faculty†

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*__NOTE:__ Some sections of this document are still under review to ensure that the graduate program is consistent with the appropriate College of Engineering and Graduate School Policies. All MS, PhD, and graduate certificate information is consistent and binding, however.

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‡Revision date

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1 Overview

The Department of Computational Mathematics, Science and Engineering (CMSE) is unique among computational academic units nationally; it is the first to comprehensively treat computation as the "triple junction" of algorithm development and analysis, high performance computing, and applications to scientific and engineering modeling and data science. This approach recognizes computation as a new discipline rather than being decentralized into isolated sub-disciplines. CMSE, jointly administered by Michigan State University's Colleges of Natural Science and Engineering, will enable application-driven computational modeling ("pull"), while also exposing disciplinary computational scientists to advanced tools and techniques (push), which will ignite new transformational connections in research and education. The Department of CMSE is focused on applications that are aligned with experimental expertise at Michigan State University. CMSE is targeting applications in the physical, biological and engineering sciences. CMSE faculty members focus on the science of algorithm development, as key methods developed in this area bridge many application core areas in science.

Scientific Computing, also referred to as "computational science," focuses on the development of predictive computer models of the world around us. As study of physical phenomena through experimentation has become impossible, impractical and/or expensive, computational modeling has become the primary tool for understandingequal in stature to analysis and experiment. Although we can now design an entire commercial aircraft through simulation alone (e.g., the Boeing 777), there are many fundamental problems in science and engineering that are beyond the scope of modern computers with current computational methods. The discipline of scientific computing is the development of new methods that make challenging problems tractable on modern computing platforms, providing scientists and engineers with key windows into the world around us.

Data Science focuses on the development of tools designed to find trends within datasets that help scientists who are challenged with massive amounts of data to assess key relations within those datasets. These key relations provide hooks that allow scientists to identify models which, in turn, facilitate making accurate predictions in complex systems. For example, a key data science goal on the biological side would be better care for patients (e.g., personalized medicine). Given a patients genetic makeup, the proper data-driven model would identify the most effective treatment for that patient.

Knowledge of the methods of scientific computing and data science is crucial to the solution of cutting-edge problems in the sciences, engineering, and many other fields. To that end, Michigan State University's Department of Computational Mathematics, Science and Engineering (CMSE) has developed several curricula at the graduate level that are intended to provide MSU students with the computational skills that they need to thrive in the 21st century workforce. Broadly speaking, this includes:

- The ability to visualize and explore large quantities of data to find important relations and trends (i.e., 'data science' and/or 'big data').
- The ability to formulate and implement software models to explain and explore a wide variety of systems and phenomena.
- The ability to effectively use modern computational hardware, including cloud computing, massively parallel supercomputers, and hardware accelerators.

MSU students have a wide variety of needs with regards to computational and data science, which may range from taking a single course on computational modeling or numerical methods through completing a PhD in scientific computing or data science. This document provides details about the courses and curricula available through the Department of Computational Mathematics, Science and Engineering, as well as policies and procedures pertaining to graduate students enrolled in degree programs in the Department.

Please note that this document is meant to be consistent with University and College of Engineering policies, as linked to in Section 12.1 of this Handbook. In the event where policies outlined in this Handbook are inconsistent with those outlined in the documents in Section 12.1, the University-level and College-level policies in those documents override this handbook.

2 Admission requirements for MS and PhD programs

Students who wish to apply to either the master's or doctoral program in Computational Mathematics, Science and Engineering must, at the time of entering the program, have a Bachelor's degree in mathematics, statistics, computer science, or any science or engineering field. Beyond this requirement, a student must have:

- Coursework in calculus through differential equations.
- A course in basic linear algebra or equivalent training through a related course.
- Competency in basic statistics through an introductory-level course or equivalent practical experience
- Ability to program competently in at least one commonly-used programming language (e.g., Python, C/C++, Java, etc.)

The competitive applicant to the PhD program will also have some experience outside of their coursework in scientific computing or data science that demonstrates their aptitude for success in a PhD program. This experience could include, but is not limited to:

- Undergraduate research experience with a strong computational component, possibly in a Research Experience for Undergraduates program or working directly with an individual faculty member at their home institution.
- An internship at a national laboratory or a company, where the student is working on a project that has a significant computational modeling and/or data science focus.
- Independent contributions to open-source programs or libraries, particularly with a computational modeling and/or data science focus.

Applications to the M.S. or PhD program in Computational Mathematics, Science and Engineering must include:

- Official transcripts for all prior undergraduate or graduate degrees and coursework
- A resume or CV
- An academic statement **of no more than two pages in length** that follows the academic statement guidelines from the College of Engineering, describing:
  - The applicant's prior programming, computational, and research experience;
  - The applicant's goals in pursuing a PhD in CMSE;

  - The CMSE faculty with whom an applicant may be interested in pursuing their dissertation research.

- A personal statement **of no more than two pages in length** that follows the personal statement guidelines from the College of Engineering, explaining why you are motivated to pursue a graduate degree in Computational Mathematics, Science and Engineering

- At least three letters of recommendation that address the applicant's past accomplishments and potential for success in pursuing independent research in computational and/or data science.

Please consult the College of Engineering's instructions on how to apply to an Engineering graduate program, and pay particular attention to the guidelines for academic and personal statements. The academic statement is particularly critical for students who are interested in being nominated for College- and University-wide fellowships, and the guidelines described by the linked document will provide the department with the needed information for making a strong case.

Note about the M.S. program: At present, admission directly to the Master of Science degree is only available in exceptional circumstances. Students interested in pursuing a graduate degree in Computational Mathematics, Science and Engineering must apply directly to the PhD program. Please contact the CMSE Director of Graduate Studies with any questions.

3 Doctor of Philosophy in CMSE

3.1 Program overview

The overall goal of the PhD program in Computational Mathematics, Science and Engineering is to give students broad and deep knowledge of the fundamental techniques used in computational modeling and data science, significant exposure to at least one application domain, and to conduct significant original research in algorithms and/or applications relating to computational and data science.

Students that have completed this PhD program will be able to:

- Analyze problems in terms of the algorithms and pre-existing computational tools required to solve a range of problems in computational and data science, and write programs to efficiently solve the problem using cutting-edge computational hardware.
- Construct and implement models and simulations of physical, biological, and social phenomena, and use these models/simulations to understand experimental or observational data and make testable predictions.
- Apply discipline-focused or methodology-focused topics in computational and data science to solve problems in the student's application domain of choice.
- Conduct original research and present it in peer-reviewed articles, a written dissertation, and orally in a variety of venues.

3.2 Program requirements

Students pursuing a PhD in CMSE must:

- Demonstrate proficiency in the following four areas: Mathematical Foundations of Data Science, Numerical Methods for Differential Equations, Parallel Programming, and Numerical Linear Algebra. Proficiency is demonstrated by passing the qualifying exam, which consists of separate subject exams in each of these topics. Students typically enroll in the four core CMSE courses that provide instruction in these subject areas (CMSE 820-823; 12 credits total). **The four subject exams must be passed with an average grade of 3.5 and no exam having a grade below 3.0**. See Sections 3.2.1 and 3.2.2 for more information.
- Complete a minimum of 18 additional credits in coursework chosen in consultation with, and approved by, the student's dissertation committee. (Students must take a minimum of 30 credit hours of non-research-based coursework beyond the Bachelor's level.) No more than 6 credits of this coursework can be below the 800 level (and all such coursework is allowable only with approval of the Graduate Director), and none of this coursework can be below the 400 level. See Section 3.2.3.

- Complete a minimum of 24, and maximum of 36, dissertation research credits (CMSE 999).
- Pass a comprehensive examination with both written and oral components no later than the end of the third year, and at least six months before the defense of their dissertation. See Section 3.2.4.
- Meet at least annually with their dissertation committee to report on progress and receive guidance. This annual meeting must include a written annual report by the committee describing the student's progress towards their degree. See Section 3.2.5.
- Complete and orally defend a dissertation based on original research in algorithms pertaining to, and/or applications of, computational and/or data science. See Section 3.2.5.
- All PhD students must complete Responsible Conduct of Research Training and submit annual reports as specified by the College of Engineering. See Section 3.2.6.

Each of these requirements is described in more detail below.

3.2.1 Core course requirement

The purpose of the four core courses (in numerical linear algebra, numerical differential equations, parallel computing, and the mathematical foundations of data science) is to provide CMSE PhD students with a broad and deep understanding of the fundamental algorithms pertaining to computational and data science.

A student with no deficiencies in their mathematics or programming background should complete all four core courses during the first year of their PhD (where "completion" assumes passage of the subject exams; see below); at the latest, all four core courses should be completed by the end of their 2nd year in the program (i.e., within 24 months of entering the program). Students can demonstrate proficiency in one or more of these core courses, and thus be excused from taking said course(s), by taking the subject exam and receiving a passing grade (see the "Qualifying Examination" section for more details). Students who demonstrate proficiency in this way are still required to meet the minimum course credit requirement for the degree (30 credits beyond the Bachelor's degree).

3.2.2 Qualifying examination

The qualifying examination in CMSE is composed of four subject exams, corresponding to the four core CMSE courses (CMSE 820-823). This requirement is intended to ensure that all students receiving a CMSE PhD achieve an acceptable level of expertise in the core numerical algorithms pertaining to computational and data science.

Each subject exam will be offered twice per academic year. All four exams will be offered immediately prior to the start of the fall semester, and each subject exam will be offered again as the final exam of the corresponding core CMSE course (parallel programming and numerical linear algebra in the fall; numerical differential equations and the mathematical foundations of data science in the spring).

Students will be given three opportunities to pass each subject exam, and must pass all four subject exams by the end of their second year in the PhD program (i.e., within 24 months of entering the program). Students beginning the PhD program in the fall term may, but are not required to, take one or more subject exams immediately upon arrival at MSU. Assuming no deficiencies, all students must take the subject exams the first time they are offered after the beginning of their first semester in the PhD program (i.e., as the final exam of the corresponding core course for students entering in the fall). Students starting the PhD program in the spring term will not have an option to take subject exams prior to the start of the spring semester; rather, they must take the subject exams for the first time at the end of the semester where each core course is offered.

The subject exams will cover a set of topics set forth by the Department, which will be provided to the students no less than two weeks in advance of the exams. The subject exams will be created and graded by a committee of CMSE faculty that must include the current or most recent instructor of that course. The purpose of the committee is to ensure consistency in topical coverage and level of difficulty between instructors and exam offerings. Subject exams may include a practical (i.e., programming) component. Passage of all four subject exams with a minimum average exam grade of 3.5 and no exam grade below 3.0 constitutes passage of the qualifying exam requirement for the department. Graduate students who receive a grade on the qualifying exam will get formal feedback within a period of two weeks on their performance on the exam.

It is possible that a student has already taken graduate coursework, or obtained equivalent practical experience, in one or more subjects that correspond to the four course CMSE graduate courses. Such a student may be excused from taking that course by demonstrating proficiency in the material by passing the appropriate subject exam, with the requirements for passage being the same as for students who choose to enroll in the course. In this case, students must still meet the course credit requirement of 30 credits past the bachelor's degree by taking other courses.

3.2.3 Cognate course requirement

The purpose of the cognate requirement is to give students in-depth expertise in one or more subject areas that are complementary to the core curriculum and which pertain to their research interests, to provide in-depth exposure to one or more areas of numerical methodology, to develop expertise in an additional area of computational or data science, and/or to fill gaps in a student's undergraduate education.

The cognate coursework must be chosen by the student in consultation with their dis-

sertation committee (or the Director of Graduate Studies, if the student has not yet formed their dissertation committee), and must include at least 12 credits of coursework addressing a single general topic or subject area. This cognate can be in any subject area, including an application area, mathematics, statistics, or computer science. A minimum GPA of 3.0 is expected in the cognate area, and no more than 6 credits can be below the 800 level (with no credits below the 400 level).

3.2.4 Comprehensive examination

There are several goals of the comprehensive examination in the CMSE PhD program. This examination enables students:

- To demonstrate mastery of the current state-of-the-art in their chosen area of specialization, as defined by the current body of literature in that field.
- To demonstrate their ability to communicate scientific goals, methods, and results in written and oral form.
- To demonstrate the ability to construct a realistic and detailed plan of research for the rest of their dissertation (which presupposes that the student has already begun their research project).

The comprehensive exam is also the first opportunity for students to receive formal feedback from their dissertation committee.

Timing: Students should plan to complete the comprehensive examination component of their PhD requirements within two years of beginning the PhD program, and no later than the end of their third year in the program. In addition, this requirement must be completed no less than six months prior to defending their dissertation.

Examination components: The comprehensive examination has two components: a written project proposal and an oral presentation.

The written project proposal should be approximately 10-15 pages long, and should include the following elements:

1. A literature survey describing the current state of their chosen area of specialization.
2. A summary of the research that the student has done so far, which should form the beginning of their dissertation research.
3. A proposal for the rest of their dissertation research, including:
   (a) The scientific motivation and significance of this work.
   (b) The specific aims of the project(s) that will be undertaken.

(c) A timeline for completion of this work.

4. A brief description of their post-PhD career goals and a description of the types of professional development opportunities that they will pursue to facilitate these goals. Such opportunities may include, but are not limited to, teaching opportunities, specific types of training (in written and/or oral communication, team skills, particular research methods, etc.), internships, acting as a mentor, or going to conferences or workshops in particular subject areas.

The written document must be sent to the dissertation committee at least two weeks (10 business days) prior to their first formal dissertation committee meeting. The first formal dissertation committee meeting is open to the public, and contains the following elements:

1. A presentation covering the first three aspects of the written proposal, which should be approximately 45 minutes long and in the style of a research seminar.

2. A public question and answer period moderated by the chairperson of the dissertation committee, which should be no longer than fifteen minutes long. Members of the audience are allowed to ask questions; the dissertation committee should remain silent during this period.

3. A private question and answer period comprised of only the student and their dissertation committee. The main goals of this questioning are to determine the soundness and feasibility of the student's dissertation research, to ensure that the student understands the broader context within which their work is being done, and to determine the practicality of the student's professional development plan. The committee is also expected to provide constructive feedback about all aspects of the student's written and oral presentations.

The possible outcomes of the comprehensive exam are:

1. **Pass without qualification:** The student has successfully demonstrated all three of the goals described at the beginning of this section.

2. **Pass with qualification:** The student has been found to be deficient in one of the goals described at the beginning of this section.

3. **Fail:** The student has significant deficiencies in more than one of the goals described at the beginning of this section.

If a student passes *without* qualification, they have formally passed their comprehensive examination requirement and no further action is needed on their part.

If a student passes *with* qualification, the dissertation committee may specify that the student take action to remediate the observed deficiency. Such actions may include, but are not limited to, extra practice with written and/or oral presentations; additional coursework; additional reading of the literature, possibly with a formal requirement to summarize their reading in written form for the committee; or a revised research plan or professional development plan. This outcome does not require an additional committee meeting; instead, the dissertation advisor is responsible for ensuring that the student undertakes any remedial actions, and will report on this to the dissertation committee at the next meeting.

Written feedback will be provided by the dissertation committee regardless of the outcome of the meeting, reflecting the consensus of the committee. Optionally, individual members of the committee may provide additional feedback. If a student fails the comprehensive examination, their dissertation committee will provide them, in writing, specific suggestions on how they can improve their performance in the future. These suggestions will be part of the committee's report on the student's progress. The student must retake the comprehensive examination within six months, and if they fail a second time they will not be allowed to continue in the PhD program.

3.2.5 Doctoral Dissertation

PhD dissertation advisor

Graduate students are assigned an advisor when they are accepted into the CMSE PhD program. Students affiliated with a particular CMSE faculty member, whether a teaching assistant, research assistant, or having a fellowship, will be advised by that faculty member. Students who are not yet affiliated with a specific faculty member will be temporarily advised by either the Director of Graduate Studies or another member of the Graduate Curriculum Committee. The most critical role of the advisor is to assist the student in developing their PhD Program Plan, which lays out plans for their proposed coursework and professional development efforts. This should ideally be done within two semesters of entering the program, and *must* be done within four semesters. The student and their advisor should also collaborate to create an Individual Development Plan, which is a document that provides a planning process that helps students to identify professional development needs, career objectives, and to facilitate communication between mentees and their mentors. The Graduate School provides resources for developing an Individual Development Plan, and students are encouraged to consult these resources prior to meeting with their mentor.

The graduate student should choose their official dissertation advisor before the end of their second academic year in the program, and ideally in the first academic year. This requires mutual consent between the professor and the student, and many factors go into this important decision. If the student has trouble in finding a willing faculty member to

serve as the their dissertation advisor, they should consult the Graduate Director and/or the Department Chairperson to help find a suitable match. It is expected that students in the CMSE PhD program will be funded by a fellowship or by a grant obtained by their dissertation advisor by no later than the end of their second year in the PhD program.

The dissertation advisor will be the chair of the student's PhD guidance committee (see the next section) and, with the help of this committee, will advise and mentor the student in their research and professional development.

Any faculty member with a non-0% percentage appointment in the Department of Computational Mathematics, Science and Engineering may serve as an advisor for a CMSE doctoral dissertation. Faculty members without an appointment in CMSE may not serve as the sole dissertation advisor for a student in the CMSE PhD program; they may, however, co-advise a CMSE PhD student along with a CMSE faculty member.

If the dissertation advisor leaves Michigan State University before the student completes their degree program, the student should consult the Graduate Director and the Departmental Chairperson to identify a suitable new advisor. It is the joint responsibility of the student and the Departmental Chairperson to make arrangements for the completion of the degree, and it requires mutual consent between the student and a new dissertation advisor. The student's former dissertation advisor may participate in their dissertation guidance committee as an external, advisory (i.e., non-voting) member to help ensure continuity in the student's research program.

If the student desires to change their dissertation advisor for any reason, the change should be requested in writing as early as possible in their graduate training program. Any plans for changing to a different advisor should be discussed with the Graduate Director, the current dissertation advisor, and the student's prospective new dissertation advisor (not necessarily together) prior to the initiation of any change. Before relations with the current dissertation advisor are severed, the student should make sure that another faculty member will serve in that capacity. Research Assistantships are normally associated with specific research programs and are not automatically transferable from one faculty member to another.

PhD dissertation guidance committee

The student's dissertation committee should be formed by the end of the summer following their first academic year in the PhD program, and **must** be formed no later than the end of their fourth semester in the program. At its early stages, this committee is primarily intended to guide students in their choice of coursework; at later stages of a student's PhD program they administer the comprehensive exam (as the student's first formal dissertation committee meeting), monitor the progress of the dissertation, and give timely and constructive feedback to the student on all aspects of their graduate work and professional development.

A student's dissertation committee is composed of a minimum of four members with the

following requirements (beyond the requirements of the MSU graduate college):

- At least two members of the committee must be Michigan State University faculty members with a non-0% appointment in CMSE, one of whom must be primarily in CMSE (i.e., CMSE must be their tenure home).
- One committee member **must** be a MSU faculty whose appointment is entirely outside of CMSE (i.e., may not have any appointment in CMSE, including a 0% appointment).

Members of external institutions or non-tenure stream faculty or academic specialists may participate in a dissertation committee in an official capacity as one of the four required faculty members, but only if an exception is granted through approval first by the Associate Dean for Graduate Education in the College of Engineering, and then by the Dean of The Graduate School. The majority of committee members must, however, be tenure-stream MSU faculty. The Chairperson of the committee (who is the student's dissertation advisor) must be an MSU faculty member with a non-0% appointment in CMSE.

The student must meet with their dissertation committee on an at least annual basis to present on their progress. Their dissertation committee will report on the outcome of this meeting in writing to the student and to the CMSE Graduate Director and the Graduate School, with students having the ability to respond to this report (also in writing). The student must display satisfactory progress every year. If the student does not display satisfactory progress, the dissertation committee should meet on a more rapid cadence to monitor and report on their progress, including providing written documentation of expectations for the student, quantifiable observations of the student's progress, and consequences of failure to meet expectations in the future. If a student is deemed by the dissertation committee to have made unsatisfactory progress for two dissertation committee meetings in a row, with at least a three month separation between meetings, the student will not be allowed to continue in the PhD program.

Dissertation and dissertation defense

The student's dissertation must be composed of novel research that advances the state-of-the-art in algorithms or applications relating to computational and/or data science.

A student may not submit their dissertation to their guidance committee without approval of their advisor. It is the dissertation advisor's responsibility to ensure that the dissertation document meets the university, college, and departmental standards for novel research, that it further represents a contribution that is significant enough to merit the receipt of a PhD, and that the document is well-written and conforms to departmental norms in terms of structure and content. More broadly, it is the advisor's responsibility to ensure that a student does not attempt to defend their dissertation until the student is ready and their dissertation is likely to be approved by their guidance committee.

A student's PhD dissertation must conform to MSU formatting standards (a MSU LaTeX thesis class template is available), and their submission-ready dissertation should be submitted to the entire dissertation committee electronically no less than two weeks (10 business days) prior to their dissertation defense. The same version of the dissertation will also be available for viewing to the entire department electronically.

The dissertation defense is an oral defense that has the following components:

1. An oral presentation, open to the public, where the student presents background material and the key findings of their dissertation in the style of a research seminar. This presentation should be approximately 45 minutes long, and does not need to comprehensively cover the student's dissertation results (i.e., a student can choose to focus on some subset of topics from their dissertation if they choose). The content of this presentation should be chosen in consultation with the student's dissertation advisor.

2. A public question and answer period following their oral presentation, wherein the student answers questions posed by non-committee members. The chair of the dissertation committee may moderate these questions and is encouraged to limit them to no more than an additional half hour.

3. A private session where the student answers questions from the committee regarding their dissertation research. At the committee's discretion, they may also question the student about the fundamentals of the algorithms or application area relating to the student's dissertation research.

The possible outcomes of the presentation of the disssertation and oral defense can be:

1. **Pass with no revisions.** The dissertation and oral defense both meet or exceed the standards for quality and original research expected of students in the CMSE program, and the dissertation committee needs no changes to be made to the dissertation. The student may immediately deposit their dissertation with the Graduate School.

2. **Pass with minor revisions.** The dissertation and oral defense both meet or exceed the standards for quality and original research expected of students in the CMSE program, but the dissertation committee deems minor changes to be made to the dissertation document (e.g., typos corrected, the addition of small amounts of clarifying text, etc.). A written list of the requested changes will be created by the dissertation committee and presented to the student, who then must make changes to their dissertation as necessary. The student's dissertation advisor(s) will make the final decision about acceptance of the written dissertation. Following acceptance by the advisor, the student may deposit their dissertation with the Graduate School.

3. **Pass with major revisions.** The dissertation and oral defense both meet the standards for quality and original research expected of students in the CMSE program, but the dissertation committee deems major revisions must be made to the dissertation. In this context, "major changes" mean the addition or removal of significant amounts of text or pursuing additional research/(re-)analysis and adding that to the dissertation document. A written list of the requested changes will be created by the dissertation committee and presented to the student, who then must make changes to their dissertation as necessary. After the student has provided the entire dissertation committee with a revised version of their dissertation (within a reasonable period of time), the dissertation must be accepted by a majority of members of the dissertation committee, one of whom **must** be the student's dissertation advisor. Following acceptance by the majority of the dissertation committee, the student may deposit their dissertation with the Graduate School.

4. **Failure.** The dissertation and/or oral defense have one or more irredeemable flaws and the majority of the dissertation committee (which may, but does not necessarily have to include, the student's dissertation advisor) agrees that an acceptable level of quality cannot be obtained in a reasonable length of time, then the dissertation will be rejected and the student will be removed from the PhD program.

After the successful completion of the oral exam and, if necessary, revisions to the dissertation, students are responsible for submitting their dissertation to the Graduate School along with a Dissertation Approval Form. Complete instructions can be found here.

3.2.6 Responsible Conduct of Research Training

All PhD students must complete Responsible Conduct of Research Training to fulfill the requirements specified by the Graduate School and administered by the College of Engineering, which addresses requirements regarding graduate training from the National Science Foundation and National Institute of Health, among other federal agencies. This training can include online training offered by the College of Engineering or one of any number of in-person training sessions.

3.2.7 Annual Progress Report

All students in the CMSE PhD program are expected to submit a Graduate Student Annual Report, which is due by January 31st of each year. To quote the linked website: "As part of this report, students will report their progress during the previous year, review their academic and professional goals, and communicate with their adviser(s) about their plans and progress toward degree completion. PhD students who do not complete the annual reporting process will have a hold placed on their accounts." Students will receive written

feedback on this progress report from their academic advisor and/or the Graduate Director within a month of submission of the report.

3.2.8 Additional notes

For an explanation of how to obtain a dual PhD in CMSE and a secondary subject, please see Section 5.

4 Master of Science in CMSE

Note about the M.S. program: At present, admission directly to the Master of Science degree is only available in exceptional circumstances. Students interested in pursuing a graduate degree in Computational Mathematics, Science and Engineering should apply directly to the PhD program. Please contact the CMSE Director of Graduate Studies with any questions.

4.1 Program overview

The overall goal of the Master of Science program in CMSE is to give students broad and deep knowledge of the fundamental techniques used in computational modeling and data science, as well as significant exposure to at least one application domain.

Students that have completed this M.S. program will be able to:

- Analyze problems in terms of the algorithms and pre-existing computational tools required to solve a range of problems in computational and data science, and write programs to efficiently solve the problem using cutting-edge computational hardware.
- Construct and implement models and simulations of physical, biological, and social situations, and use these models/simulations to understand experimental or observational data.
- Apply discipline-focused or methodology-focused topics in computational and data science to solve problems in the student's application domain of choice.

4.2 Program requirements

Students pursuing a M.S. in CMSE must complete a minimum of 30 credits of graduate coursework, at least 18 credits of which must be CMSE courses. There are two possible 'tracks' in the program: Plan A, which includes a thesis, or Plan B, which is entirely coursework-based. The student's program of study must be approved by the student's guidance committee within one semester of entering the graduate program. The student must meet the requirements specified below:

Common Requirements for Plan A and Plan B:

1. Complete a minimum of three of the following four core CMSE courses **with an average grade of at least 3.3 on the corresponding subject exams and no grade lower than 3.0** (at least 9 credits):
    - CMSE 820, Mathematical Foundations of Data Science (3 credits)
    - CMSE 821, Numerical Methods for Differential Equations (3 credits)

- CMSE/CSE 822, Parallel Programming (3 credits)
- CMSE 823, Numerical Linear Algebra, I (3 credits)

2. Complete a minimum of 12 credits in complementary coursework chosen in consultation with, and approved by, the student's academic advisor. (Note: the academic advisor for M.S. students is typically the CMSE Graduate Director.)

3. All M.S. students must complete Responsible Conduct of Research Training and submit annual reports as specified by the College of Engineering.

Additional Requirements for Plan A: In addition to requirements 1-3 above, the student must complete a thesis based on original research on a problem in computational and/or data science. The student will enroll in a minimum of 4 and a maximum of 8 credits of CMSE 899 (Master's Thesis Research). This thesis research will culminate in a written thesis to be submitted to, and accepted by, a guidance committee.

Additional Requirements for Plan B: Requirements 1-3 will apply. In lieu of pursuing original research in computational and/or data science, the student will enroll in additional coursework. This coursework may include up to 3 credits of CMSE 891 (Independent Study) if approved by the student's academic advisor.

4.2.1 Selection of thesis advisor

Any faculty member with a non-0% percentage appointment in the Department of Computational Mathematics, Science and Engineering may serve as an advisor for a Master's thesis for a student pursuing Plan A. With the permission of the CMSE Graduate Director and CMSE Graduate Studies Committee, a faculty member without an appointment in CMSE may serve as a Master's thesis advisor.

The thesis advisor should be chosen as soon as possible after the student has decided to pursue the Plan A degree, ideally no later than the beginning of the student's second semester in the graduate program. At the latest, an advisor should be selected prior to enrolling in CMSE 899 (Master's Thesis Research).

4.2.2 Formation of the guidance committee

The purpose of the M.S. guidance committee is primarily to provide advice to students about coursework selection and professional development, and to assist them in the development of their M.S. Program Plan, which must be created during the first semester the student is enrolled in the program. In the case of students pursuing a Plan A Master's degree, the guidance committee is also responsible for advising the student in their choice of research topic, implementation, analysis, and presentation of said topic, and accepting the written thesis.

All students pursuing a Master's degree in CMSE will be assigned a guidance committee upon entrance to the degree program. For students pursuing a Plan A degree, their guidance committee is composed of their graduate thesis advisor. Students pursuing a Plan B degree will be assigned a CMSE faculty member as the sole member of their guidance committee. This faculty member will be either the CMSE Graduate Director or a member of the graduate studies committee that has been chosen because their research expertise complements the student's educational and career goals. Students engaged in either track of the Master's degree are **strongly encouraged** to collaborate with their guidance committee to create an Individual Development Plan, which is a document that provides a planning process that helps students to identify professional development needs, career objectives, and to facilitate communication between mentees and their mentors. The Graduate School provides resources for developing an Individual Development Plan, and students are encouraged to consult these resources prior to meeting with their guidance committee.

4.2.3 Thesis defense and final oral examination

Students pursuing a Plan A thesis submit a written thesis to their guidance committee for approval two weeks before the final date for thesis deposition during their last semester in the Master's degree program. This thesis must be approved by their thesis advisor prior to submission to the entire committee. (Note: this date can be found in the MSU Academic Calendar, but is typically the Monday after the end of final exam week.) Submission should be electronic, and preferably via PDF. Students who wish to use LaTeXshould use the MSU LaTeX thesis class, which will ensure that their thesis conforms to the Graduate School Thesis Formatting Guide.

The guidance committee will provide writtennte feedback on the thesis within one week, and the student is expected to make any necessary revisions and get approval from their guidance committee in a timely manner. After their guidance committee approves of the thesis, it must be submitted, along with an Approval Form, to the Graduate School. Complete instructions can be found here.

No oral examination is required for the Plan A Master's degree. If a student requests one, the same procedure as is used for the PhD oral defense shall be used. See Section 3.2.5 for additional details.

5 Dual PhD in CMSE and a second subject

The Department of Computational Mathematics, Science and Engineering strongly supports interdisciplinary PhD programs centering on the student's pursuit of a project that combines a specific application or algorithmic domain and the goals of the CMSE PhD program. In order to qualify for such a program, the student's dissertation must include significant research contributions in both disciplines.

MSU allows "dual PhD" programs for individual students to span graduate programs, as long as the graduate programs involved agree to do so - see the MSU guidelines on dual major doctoral degrees for more information. It is typical that a student enters into a dual PhD program after starting graduate school at MSU in their primary graduate program, and then arranges the secondary affiliation upon choice of a research project and advisor; however, a student could in principle be admitted as a dual PhD student with concurrence of the two graduate programs.

The Department of Computational Mathematics, Science and Engineering has developed a set of guidelines for these dual major PhDs, which should apply to all students wishing to pursue a PhD jointly between CMSE and another program. These guidelines are as follows:

1. A request for the dual major degree must be submitted for approval to the Graduate Directors of both departments and the Dean of the Graduate School within one semester following its development and within the first two years of the students enrollment at Michigan State University. A copy of the guidance committee report must be attached. This program must also be approved by the College of the student's primary graduate program and by the student's dissertation advisor.

2. Of the two departments involved, one must be the student's primary affiliation and the other is their secondary affiliation. (Their primary dissertation advisor can be in either department.) The degree is then called "PhD in Primary & Secondary" – for example, for a student with a primary affiliation in Chemistry and a secondary affiliation in CMSE, the name would be "PhD in Chemistry and Computational Mathematics, Science and Engineering." Admission requirements to graduate school are based on the primary department.

3. **Qualifying Exam:** Students whose primary department is CMSE must select and pass three of the four subject exams (as detailed in Section 3.2.2), and students whose secondary department is CMSE must select and pass two of the four subject exams. This is typically achieved by the student taking the appropriate core CMSE graduate courses and then taking the subject exam that is the final exam for that course. The average of the subject exam grades must be at least 3.5, with no one grade being less than 3.0, in order for this requirement to be fulfilled.

4. **Cognate coursework requirement:** Students must determine, in discussion with their dissertation committee, a comprehensive set of courses that fulfills the requirements of both departments. The CMSE PhD program's cognate requirement is typically fulfilled by taking coursework in the non-CMSE department, with the maximum number of required credits being 120% of the credit requirement in the primary graduate program, excluding research credits. Dual PhD students must take a minimum of 12 credits of coursework in computationally-focused courses. This explicitly includes all CMSE graduate courses aside from CMSE 801 and 802, and may also include computationally-intensive courses in other departments at the discretion of the dissertation committee.

5. **Research credit requirement:** Students must take at least 24, and no more than 36, dissertation research credits in their primary department (CMSE 999 or its equivalent).

6. **Dissertation Committee:** Students must form a PhD dissertation committee that includes faculty from both their primary and secondary departments, and which satisfies to the greatest extent possible the requirements for the composition of a dissertation committee from both departments. The dissertation committee must include at least one faculty program advisor whose tenure home is in each of the two departments. The dissertation committee must be formed and meet prior to the end of the student's second year in a PhD program in order to submit the dual PhD request to the Graduate School. This meeting does not have to be the same committee meeting where the comprehensive exam takes place.

7. **Comprehensive Exam:** Comprehensive examinations are specified according to the guidelines of the primary department, and in CMSE the comprehensive examination is generally the first formal meeting of the dissertation committee. This meeting typically includes a presentation of the dissertation proposal (although see the previous point). For dual PhDs where CMSE is the secondary department: In the case where the comprehensive exam is part of the first formal dissertation committee meeting, this meeting should explicitly include discussion of the student's career goals and the creation of a professional development plan (as detailed in the CMSE PhD program description). In the case where the comprehensive exam takes some other form, this discussion should be part of the first formal dissertation committee meeting. This requirement should be fulfilled after passage of the qualifying exam, and no later than the end of the student's third year.

8. **Dissertation and dissertation defense:** The student's dissertation must be composed of novel research that advances the state-of-the-art in algorithms or applications relating to computational and/or data science, and must include significant intellectual contributions to both disciplines. The details of the dissertation and defense are specified according to the guidelines of the primary department.

9. **Responsible Conduct of Research training:** All PhD students must complete Responsible Conduct of Research Training through their primary department.

Students whose primary department is CMSE must adhere to the requirements specified in the CMSE PhD program description (Section 3.2) with regards to the number of opportunities to pass exams, GPA requirements, and timelines.

If a student decides to leave the interdisciplinary degree program, their PhD program requirement reverts to the requirements of their primary affiliation. In this circumstance, the student should consult with the graduate director in their primary department to determine if any further action is needed.

6 Graduate Certificates

6.1 Admission and graduation requirements

Graduate students enrolled at Michigan State University in any discipline or college may pursue this graduate certificate. Furthermore, students can apply for the certificate at any time prior to receiving their primary degree (either Masters or PhD), and must apply for the certificate after taking all the necessary courses.

Graduate students pursuing either the Master of Science in CMSE, the Doctor of Philosophy in CMSE, or a dual PhD in CMSE and a second subject **may not receive** either the Graduate Certificate in Computational Modeling or the Graduate Certificate in High Performance Computing.

In order to obtain this graduate certificate the student must have at least a 3.0 average in the courses that are applied to the certificate. Courses where the student has received a grade below 2.5 **may not apply** to the requirements of either graduate certificate. In addition, students must be in good academic standing.

To apply for this certificate, please consult the CMSE website for the application information. You will need the signature of your academic advisor as well as the CMSE Director of Graduate Studies.

6.2 Graduate Certificate in Computational Modeling

6.2.1 Certificate description

The Graduate Certificate in Computational Modeling is intended for students with little or no prior programming or computational modeling experience. The purpose of this certificate is to complement graduate students' degree programs with a set of courses that teach students critical skills in computer programming, data manipulation and visualization, and computational modeling.

This is a transcriptable certificate, meaning that the certificate name will show up on a student's transcript in addition to the courses that were taken.

Students that have completed this certificate will be able to:

- Demonstrate a basic understanding of functional computer programming as applied to a range of problems in computational and data science.
- Analyze problems in terms of the algorithms and pre-existing computational tools required to solve a range of problems in computational and data science, and write a program to efficiently solve the problem.
- Construct and implement models and simulations of physical, biological, and social situations, and use these models/simulations to understand experimental or observational data.

- Apply some subset of discipline-focused or methodology-focused topics in computational and data science to solve problems in the student's primary discipline.

6.2.2 Certificate requirements

The Graduate Certificate in Computational Modeling consists of at least three courses comprising a minimum of 9 credit hours, taken from the two categories listed below. This certificate program is intended for graduate students in any discipline with interest in applying computational and data science approaches to their research problems, or who generally desire a broad education in computational modeling and computational methodology.

The requirements for the certificate are:

1. Any two of following CMSE graduate courses (6 credits):

    - CMSE-801, Introduction to Computational Modeling (3 credits)
    - CMSE-802, Methods in Computational Modeling (3 credits)
    - CMSE-820, Mathematical Foundations of Data Science (3 credits)
    - CMSE-821, Numerical methods for differential equations
    - CMSE/CSE-822, Parallel programming (3 credits)
    - CMSE-823, Numerical Linear Algebra, I (3 credits)

2. One or more additional courses, which may include further CMSE courses at the 400 level or above (including from the list of CMSE graduate courses in List 1), courses from the list of non-CMSE courses in Section 7, or other computational science or data science-focused courses at the 400 level or above as approved by the CMSE Graduate Director (3 or more credits).

6.3 Graduate Certificate in High Performance Computing

6.3.1 Certificate description

The Graduate Certificate in High Performance Computing is intended for graduate students in any discipline **who have significant prior computational experience**. The purpose of this certificate is to complement students' degree programs with a set of courses that provides students with a broad exposure to parallel computing methodology, and give them experience with computational and data science challenges that require parallel and/or high-performance computing in order to solve effectively.

This is a transcriptable certificate, meaning that the certificate name will show up on a student's transcript in addition to the courses that were taken.

Students that have completed this certificate will be able to:

- Demonstrate a high-level understanding of functional and object-oriented computer programming as applied to a range of problems in computational and data science.
- Analyze problems in terms of the algorithms and pre-existing computational tools required to solve a range of problems in computational and data science, and write a program to efficiently solve the problem on modern parallel computers and/or specialized hardware (e.g., graphics processing units).
- Construct and implement models of a variety of systems using modern parallel programming techniques and software development techniques, and use these models/simulations to gain understanding of these systems.
- Apply some subset of discipline-focused or methodology-focused topics in computational and data science to solve problems in the student's primary discipline.

6.3.2 Certificate requirements

The proposed Graduate Certificate in High Performance Computing consists of at least three courses comprising a minimum of 9 credit hours, taken from the two categories listed below. The targets of the certificate program are graduate students in any discipline with interest in applying computational and data science approaches that require parallel and/or high-performance computing to their research problems, or who generally desire an education in parallel computational methodology.

Note that credit from courses whose focus is largely or primarily an introduction to programming and/or basic numerical methods (i.e., CMSE 801, CMSE 802, CSE 801, or other comparable courses) **will not count for credit** toward this certificate. In addition, 400-level computational coursework may not count for credit toward this certificate without the permission of the CMSE graduate certificate advisor. The primary circumstance where a 400-level course may be acceptable for credit toward this certificate program is when an equivalent 800-level course is unavailable (e.g., a highly specialized 400-level combined undergraduate and graduate course.) Students that have questions about any particular course are strongly encouraged to consult the CMSE Director of Graduate Studies.

The requirements for the certificate are:

1. CMSE/CSE-822, Parallel Computing (3 credits)
2. Two or more additional courses, which may include further CMSE courses at the 800 level or above, courses from the list of non-CMSE courses in Section 7, or any other 800- or 900-level computational science or data science-focused courses as approved by the CMSE graduate advisor (6 or more credits).

7 Graduate courses

7.1 CMSE graduate courses

Note: this list includes cross-listed courses!

CMSE 801, Introduction to Computational Modeling. Introduction to computational modeling using a wide variety of application examples. Algorithmic thinking and model building, data visualization, numerical methods, all implemented as programs. Command line interfaces. Scientific software development techniques including modular programming, testing, and version control. Recommended background: one semester of introductory calculus. **(3 credits)**

CMSE 802, Methods in Computational Modeling. Standard computational modeling methods and tools. Programming and code-management techniques. Recommended background: CMSE 801 or equivalent experience. **(3 credits)**

CMSE 820, Mathematical Foundations of Data Science. Introduces students to the fundamental mathematical principles of data science that underlie the algorithms, processes, methods, and data-centric thinking. Introduces students to algorithms and tools based on these principles. Recommended background: CMSE 802 or equivalent experience. Differential equations at the level of MTH 235/255H/340+442/347H+442. Linear algebra at the level of MTH 390/317H. Probability and statistics at the level of STT 231. **(3 credits)**

CMSE 821, Numerical Methods for Differential Equations. Numerical solution of ordinary and partial differential equations, including hyperbolic, parabolic, and elliptic equations. Explicit and implicit solutions. Numerical stability. Recommended background: CMSE 802 or equivalent experience. Differential equations at the level of MTH 235/255H/340+442/347H+442. Linear algebra at the level of MTH 390/317H. **(3 credits)**

CMSE/CSE 822, Parallel Computing. Core principles and techniques of parallel computation using modern supercomputers. Parallel architectures. Parallel programming models. Principles of parallel algorithm design. Performance analysis and optimization. Use of parallel computers. Recommended background: One semester of introductory calculus. Ability to program proficiently in C/C++, basic understanding of data structures and algorithms (both at the level of CSE 232). Basic linear algebra and differential equations. **(3 credits)**

CMSE 823, Numerical Linear Algebra, I. Convergence and error analysis of numerical methods in applied mathematics. Recommended background: CMSE 802 or equivalent experience; Linear algebra at the level of MTH 414. **(3 credits)**

CMSE 890, Selected Topics in Computational Mathematics, Science, and Engi-

neering. Topics selected to supplement and enrich existing courses and lead to the development of new courses. Recommended background varies with topic and instructor. **(1-4 credits)** Note: A student may earn a maximum of 12 credits in all enrollments of this course.

CMSE 891, Independent Study in Computational Mathematics, Science, and Engineering. Topics selected to supplement and enrich existing courses. Recommended background varies with topic and instructor. **(1-4 credits)** Note: A student may earn a maximum of 6 credits in all enrollments of this course.

CMSE 899, Master's Thesis Research. Master's thesis research. **(1-6 credits)** Note: A student may earn a maximum of 8 credits in all enrollments for this course.

CMSE 999, Doctoral Dissertation Research. Doctoral dissertation research. **(1-24 credits)** Note: A student may earn a maximum of 36 credits in all enrollments for this course.

7.2 Non-CMSE computational and data-science courses

Note: this list contains courses that have been pre-screened and will automatically be accepted for the CMSE graduate certificates and degrees (modulo limits described in the individual program descriptions). Please note that other computationally-focused MSU courses may also be acceptable for these programs! Consult departmental listings in the MSU course catalog for the most timely information about appropriate courses, and email the CMSE Director of Graduate Studies if you have questions about courses that may count toward a CMSE graduate certificate or degree.

7.2.1 Courses at the 400 level

- BMB/MMG/PLB-400, Introduction to Bioinformatics (3 credits)
- CEM-481, Computational Chemistry (3 credits)
- ME-475, The Use of Finite Element Methods (3 credits)
- MTH-451, Numerical Analysis, I (3 credits)
- MTH-452, Numerical Analysis, II (3 credits)
- PHY-480, Computational Physics (3 credits)
- STT-461, Computations in Probability and Statistics (3 credits)
- STT-465, Bayesian Statistical Methods (3 credits)

7.2.2 Courses at the 800 and 900 level

- AST-911, Numerical Techniques in Astronomy (2 credits)
- CE-822, Ground Water Modeling (3 credits)
- CE-823, Stochastic Ground Water Modeling (3 credits)
- CE/ME-872, Finite Element Methods (3 credits)
- CEM-883, Computational Quantum Chemistry (3 credits)
- CEM-888, Computational Chemistry (3 credits)
- CSE-836, Prob. Models and Algorithms in Comp. Bio. (3 credits)
- CSE-845, Multi-disc. Rsrch. Meth. for Study of Evolution (3 credits)
- CSE-881, Data Mining (3 credits)
- CSE-912, Artificial Life Communities in Science and Engineering (3 credits)
- ECE-837, Comp. Methods in Electromagnetics (3 credits)
- ECE-929D, Fast Computational Methods in Electromagnetics and Acoustics (3 credits)
- ME-835, Turbulence Modeling and Simulation (3 credits)
- ME-840 Comp. Fluid Dynamics and Heat Transfer (3 credits)
- MTH-850, Numerical Analysis, I (3 credits)
- MTH-851, Numerical Analysis, II (3 credits)
- MTH-852, Numerical Methods for ODEs (3 credits)
- MTH-950, Numerical Methods for PDEs (3 credits)
- MTH-951, Numerical Methods for PDEs, II (3 credits)
- MTH-995, Special Topics in Numerical Analysis (3 or more credits)
- PHY-915, Computational Condensed Matter Physics (2 credits)
- PHY-919, Modern Electronic Structure Theory (2 credits)
- PHY-950, Data analysis methods (2 credits)

- PHY-998, Computational Tools for Nuclear Physics (2 credits)
- PLB-810, Theories and practices in bioinformatics (3 credits)
- PSY-992, Computer programming for behavioral scientists (3 credits)
- QB-826, Intro to Quantitative Biology Techniques (1 credit)
- STT-802, Statistical Computation (3 credits)
- STT-874, Introduction to Bayesian Analysis (3 credits)

8 Policy regarding academic performance[1]

When a student is admitted into the CMSE graduate program, it is with the full expectation that they will thrive academically as scholars and developing scientists. However, sometimes a student's academic performance does not meet the expectations of the student and our faculty. This section deals with problems and standards for academic performance.

8.1 Grades

College Regulations: A 3.0 cumulative grade point average (GPA) is a 3.0 average on coursesin the student's Program Plan. (Note that courses that have already been taken cannot be dropped from the Program Plan.) Research credits are not considered in determining the GPA for either the University or College standard, and courses not in the Program Plan do not count toward the College standard.
Department Regulations: The accumulation of grades below 3.0 in more than three courses of three or more credits or "deferred" in more than three courses of three or more credits at any given time, or a combination of the above in excess of four courses automatically removes the student from candidacy for the degree. Students will be notified of this in writing via email or paper mail. Until the first official Guidance Committee report is filed, all courses on the student's record are considered part of the required program in their Program Plan

8.2 Progress toward degree

Attainment of the minimum GPA is, however, an insufficient indicator of potential for success in other aspects of the program and in the research field. The student's Guidance committee is responsible for evaluation of the student's research competency and their rate of progress toward their degree.

To remain in good standing, the student also needs to follow Departmental as well as University rules for completing their degree requirements in a timely manner, and a student must continuously be making **satisfactory progress** towards his/her degree. The Department's criteria for satisfactory academic progress includes: course credits completed per semester, the nature of these courses, the grades received, successful completion of required subject/qualifying/comprehensive examinations, and progress in completing M.S. or Ph.D. dissertation research. A student making satisfactory progress will be on track to complete their M.S. in no more than two years of full-time study, and a Ph.D. in approximately six years of full-time study beyond the Bachelor's degree. In addition to satisfactory progress toward completing the degree, continuation of graduate support would depend upon the following: the recipient has performed the assigned duties satisfactorily; past level of support and total number of semesters of support; the availability of funds to continue the current

[1]Adapted with permission from the MSU Department of Physics & Astronomy Handbook for Graduate Students, Section XIII

level of financial assistance; the needs of the Department for the particular services for which the recipient is qualified to perform. When resources for financial aid are limited and the demand of aid exceeds the amount of funds available, continuation of financial aid for an individual will depend upon merit relative to others requesting aid and the needs of the Department to fulfill its overall mission of teaching, research, and outreach.

If a student is not making **satisfactory progress** towards his/her degree as defined above, within 30 days following the documentation of the deficiency, the student will receive a letter from the Graduate Director specifying deficiencies and describing the exact steps, with a time table, to get back to good standing. There will be a space on this letter for the student to respond in writing (within no more than two weeks after receipt of the letter) if they disagree either with the deficiencies listed or with the steps and time table for remediation. These responses will be a part of the student's file.

It is a disservice to permit a student to continue toward the advanced degree without the necessary qualifications for retention, including a high level of motivation, commitment, and aptitude. Judgment regarding retention is made by the student's graduate advisor and/or the Guidance Committee, in consultation with the Graduate Program Director and if needed the Department Chairperson. If, based on the annual evaluation, the majority of the Guidance Committee decides that a student lacks such standards, has been notified of deficiencies, and has not rectified these deficiencies within a reasonable period of time, he/she may be asked to withdraw according to the procedures as defined in the Graduate Student Rights and Responsibilities document, which can be obtained at www.msu.edu/students/Splife/gradrights.html.

8.3 Student rights

The student has a right to receive a written warning when academic performance is judged to be unsatisfactory (see the document Graduate Students Rights and Responsibilities (GSSR) sections 2.4.8.1 and 2.4.8.2). The student has a right to access their educational records including the academic file the department keeps on them (GSSR 3.2.3), but excluding any confidential materials (such as the letters of recommendation submitted on the student's behalf if the student waived the right to see these letters). Request to view and/or copy the file should be made in writing through the department Graduate Secretary.

8.4 Qualifying and Comprehensive Examinations

If the student does not satisfy the Qualifying exam requirement (see Section 3.2.2), they will not be allowed to proceed towards the M.S./Ph.D. degree. If after successfully completing the Qualifying exam the student fails to pass in the Ph.D. Comprehensive examination (see Section 3.2.4), he/she will be dismissed from the program.

8.5 Ph.D. oral examination

The Oral examination for the Ph.D. degree is pass/fail. A student who fails the Ph.D. Dissertation Defense will be given one opportunity to repeat the examination after an adequate amount of time to preprae has been given – a period of time that must be at least one month, but no more than six months. If the student fails the exam a second time, he/she will be dismissed from the program.

8.6 Further information

Further information on rights and responsibilities of graduate students can be found at the website of the Office of the Ombudsman, http://www.msu.edu/unit/ombud/.

9 Academic Integrity Policy[2]

9.1 The MSU perspective

Each graduate student shall review the document Guidelines for Integrity in Research and Creative Activities and discuss its contents with their advisor. The conduct of research and creative activities by faculty, staff, and students is central to the mission of Michigan State University and is an institutional priority. Faculty, staff, and students work in a rich and competitive environment for the common purpose of learning, creating new knowledge, and disseminating information and ideas for the benefit of their peers and the general public. The stature and reputation of MSU as a research university are based on the commitment of its faculty, staff, and students to excellence in scholarly and creative activities and to the highest standards of professional integrity.

As a partner in scholarly endeavors, MSU is committed to creating an environment that promotes ethical conduct and integrity in research and creative activities. Innovative ideas and advances in research and creative activities have the potential to generate professional and public recognition and, in some instances, commercial interest and financial gain. In rare cases, such benefits may become motivating factors to violate professional ethics. Pressures to publish, to obtain research grants, or to complete academic requirements may also lead to an erosion of professional integrity.

Breaches in professional ethics range from questionable research practices to misconduct in research, teaching, and in completing coursework. The primary responsibility for adhering to professional standards lies with the individual scholar. It is, however, also the responsibility of advisors and of the disciplinary community at large. Passive acceptance of improper practices lowers inhibitions to violate professional ethics.

Integrity in research and creative activities is based not only on sound disciplinary practice but also on a commitment to basic personal values such as fairness, equity, honesty, and respect. These guidelines are intended to promote high professional standards by everyone faculty, staff, and students alike.

For further information and training, graduate students are encouraged to participate in the Responsible Conduct of Research workshop series, sponsored by the Office of the Vice President for Research and Graduate Studies and by the Graduate Dean. Information on this series is available at the graduate school web site. Note that graduate students are **required** to participate in Responsible Conduct of Research training every year that they are enrolled in either the M.S. or PhD program. This training is provided online through the College of Engineering.

9.1.1 Key principles

Integrity in research and creative activities embodies a range of practices that includes:

[2]Adapted with permission from the MSU Department of Electrical and Computer Engineering Graduate Handbook, Section 8

- Honesty in proposing, performing, and reporting research.
- Recognition of prior work.
- Confidentiality in peer review.
- Disclosure of potential conflicts of interest.
- Compliance with institutional and sponsor requirements.
- Protection of human subjects and humane care of animals in the conduct of research.
- Collegiality in scholarly interactions and sharing.
- Adherence to fair and open relationships between senior scholars and their co-workers.

Honesty in proposing, performing, and reporting research: The foundation underlying all research is uncompromising honesty in presenting one's own ideas in research proposals, in performing one's research, and in reporting one's data. Detailed and accurate records of primary data must be kept as unalterable documentation of one's research and must be available for scrutiny and critique. It is expected that researchers will always be truthful and explicit in disclosing what was done, how it was done, and what results were obtained. To this end, research aims, methods, and outcomes must be described in sufficient detail such that others can judge the quality of what is reported and can reproduce the data. Results from valid observations and tests that run counter to expectations must be reported along with supportive data. See MSU's Procedures Concerning Allegations of Misconduct in Research and Creative Activities for more information.

Recognition of prior work: Research proposals, original research, and creative endeavors often build on one's own work and also on the work of others. Both published and unpublished work must always be properly credited. Reporting the work of others as if it were one's own is plagiarism. Graduate advisors and members of guidance committees have a unique role in guiding the independent research and creative activities of students. Information learned through private discussions or committee meetings should be respected as proprietary and accorded the same protection granted to information obtained in any peer review process.

Confidentiality in peer review: Critical and impartial review by respected disciplinary peers is the foundation for important decisions in the evaluation of internal and external funding requests, allocation of resources, publication of research results, granting of awards, and in other scholarly decisions. The peer-review process involves the sharing of information for scholarly assessment on behalf of the larger disciplinary community. The integrity of this process depends on confidentiality until the information is released to the public. Therefore, the contents of research proposals, of manuscripts submitted for publication, and of other scholarly documents under review should be considered privileged

information not to be shared with others, including students and staff, without explicit permission by the authority requesting the review. Ideas and results learned through the peer-review process should not be made use of prior to their presentation in a public forum or their release through publication.

Disclosure of potential conflicts of interest: There is real or perceived conflict of interest when a researcher has material or personal interest that could compromise the integrity of the scholarship. It is, therefore, imperative that potential conflicts of interest be considered and acted upon appropriately by the researcher. Some federal sponsors require the University to implement formal conflict of interest policies. It is the responsibility of all researchers to be aware of and comply with such requirements.

Compliance with institutional and sponsor requirements: Investigators are granted broad freedoms in making decisions concerning their research. These decisions are, however, still guided, and in some cases limited, by the laws, regulations, and procedures that have been established by the University and sponsors of research to protect the integrity of the research process and the uses of the information developed for the common good. Although the legal agreement underlying the funding of a sponsored project is a matter between the sponsor and the University, the primary responsibility for management of a sponsored project rests with the principal investigator and his or her academic unit.

Protection of human subjects and humane care of animals in the conduct of research: Research techniques should not violate established professional ethics or federal and state requirements pertaining to the health, safety, privacy, and protection of human beings, or to the welfare of animal subjects. Whereas it is the responsibility of faculty to assist students and staff in complying with such requirements, it is the responsibility of all researchers to be aware of and to comply with such requirements. Please consult the websites of the MSU Human Research Protection Program and Institutional Animal Care and Use Committee for further information about these requirements, and see Section 9.3 for further information about research involving human subjects.

Collegiality in scholarly interactions and sharing of resources: Collegiality in scholarly interactions, including open communications and sharing of resources, facilitates progress in research and creative activities for the good of the community. At the same time, it has to be understood that scholars who first report important findings are both recognized for their discovery and afforded intellectual property rights that permit discretion in the use and sharing of their discoveries and inventions. Balancing openness and protecting the intellectual property rights of individuals and the institution will always be a challenge for the community. Once the results of research or creative activities have been published or otherwise communicated to the public, scholars are expected to share materials and information on methodologies with their colleagues according to the tradition of their discipline. Please consult the MSU Guidelines on Authorship and Institutional Data Policy for more information.

Adherence to fair and open relationships between senior scholars and their coworkers: The relationship between senior scholars and their coworkers should be based on mutual respect, trust, honesty, fairness in the assignment of effort and credit, open communications, and accountability. The principles that will be used to establish authorship and ordering of authors on presentations of results must be communicated early and clearly to all coworkers. These principles should be determined objectively according to the standards of the discipline, with the understanding that such standards may not be the same as those used to assign credit for contributions to intellectual property. It is the responsibility of the faculty to protect the freedom to publish results of research and creative activities. The University has affirmed the right of its scholars for first publication except for exigencies of national defense. It is also the responsibility of the faculty to recognize and balance their dual roles as investigators and advisors in interacting with graduate students of their group, especially when a student's efforts do not contribute directly to the completion of his or her degree requirements.

Faculty advisors have a particular responsibility to respect and protect the intellectual property rights of their advisees. A clear understanding must be reached during the course of the project on who will be entitled to continue what part of the overall research program after the advisee leaves for an independent position. Faculty advisors should also strive to protect junior scholars from abuses by others who have gained knowledge of the junior scholar's results during the mentoring process, for example, as members of guidance committees.

9.2 Misconduct in research and creative activities

Federal and University policies define misconduct to include fabrication (making up data and recording or reporting them), falsification (manipulating research materials, equipment or processes, or changing or omitting data such that the research is not accurately represented in the record), and plagiarism (appropriation of another person's ideas, processes, results, or words without giving appropriate credit). Serious or continuing non-compliance with government regulations pertaining to research may constitute misconduct as well. University policy also defines retaliation against whistle blowers as misconduct. Misconduct does not include honest errors or honest differences of opinion in the interpretation or judgment of data.

The University views misconduct to be the most egregious violation of standards of integrity and as grounds for disciplinary action, including the termination of employment of faculty and staff, dismissal of students, and revocation of degrees. It is the responsibility of faculty, staff, and students alike to understand the University's policy on misconduct in research and creative activities, to report perceived acts of misconduct of which they have direct knowledge to the University Intellectual Integrity Officer, and to protect the rights and privacy of individuals making such reports in good faith.

9.3 Research involving human subjects

The University Committee on Research Involving Human Subjects (UCRIHS) is an Institutional Review Board (IRB). Federal regulations and University policy require that all research projects involving human subjects and materials of human origin be reviewed and approved by an IRB before initiation. Research is defined as "a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge." The "generalizable knowledge" criteria may include developing publications/papers, theses/dissertations, making public presentations, etc. A human subject of research is a) a living individual from whom an investigator obtains data by interaction or intervention or b) identifiable private information.

All research involving human subjects and/or data collected from living human subjects (including preexisting data) is subject to UCRIHS review. Instructions for applying for approval are available at the Human Research Protection Program website.

10 Student conduct and conflict resolution

10.1 Student Conduct

Graduate students are an integral and highly valued part of the department's research and teaching programs. Professional behavior is expected from all CMSE graduate students at all times. In this context, professional behavior has several key aspects. You are expected:

- To work responsibly toward completion of your chosen degree in a timely fashion.
- To contribute to your scholarly discipline by learning the theoretical and practical aspects of your chosen field of study, by constructing new knowledge, and by applying that knowledge to new problems.
- To exercise the highest integrity in all aspects of your work at Michigan State University, particularly with regards to research and teaching.
- To treat fellow students, staff, and faculty with the courtesy and respect with which you would like to be treated in order to create an environment of collegiality and collaboration. In particular, this means avoiding any inappropriate behavior that may be interpreted as harassment.
- To devote the same seriousness to instructional duties (both undergraduate and graduate) that you would expect from your own instructors.

In addition to these broad expectations regarding your conduct while at Michigan State University, please consult the Spartan Life Student Handbook, which has specific policies, ordinances, and regulations that define additional University expectations. Further important policy documents that pertain to graduate student conduct are the MSU Student Rights and Responsibilities document, as well as the MSU Graduate School's Graduate Student Rights and Responsibilities document. Please note that failure to conform to the expected level of professionally accepted behavior may result in dismissal from the graduate program.

10.2 Conflict Resolution

Occasionally problems involving students, teaching assistants, research assistants, staff, and faculty arise. Many of these problems are likely to be resolved by informal discussions with the Graduate Director or with the Department Chair. You are encouraged to contact these individuals with any issues that may arise, starting with the Graduate Director. If the Graduate Director is the person you have a problem with, or you are otherwise uncomfortable discussing the issue with them, you should go directly to the Department Chair.

In rare cases, however, some conflicts may need a more formal mechanism for resolution. Graduate students in the Department of Computational Mathematics, Science and Engineering are officially in the College of Engineering. The grievance procedure for College of

Engineering graduate students is described by this document, which is based on the template provided by the University Ombudsperson. This template is in accordance with the agreement between the Graduate Employee Union and Michigan State University, as described in detail in the MSU/Graduate Employee Union Contract.

11 Policies relating to graduate assistantships[3]

All doctoral students in the Computational Mathematics, Science and Engineering PhD program are expected to be employed as either assistants in our teaching programs (TA) or as assistants in one of the research groups within the department (RA). Professional behavior is expected from students in these positions, and students in our program carry out their duties at a high level of performance. Teaching Assistants are governed by the MSU/GEU contract (http://grad.msu.edu/geu/). Incoming students may be supported by either a TA or an RA; after their first two years, all students are expected to be supported by research assistantships for the duration of their PhD program.

11.1 Teaching Assistantships

Graduate Students who are assigned teaching assistantships are **required to attend** a TA Orientation session prior to their first semester as a TA at Michigan State University. These sessions may be offered by the College of Engineering or the Graduate School. You will receive an email from the Graduate Director with instructions in this regard, if relevant.

International students who are not native speakers of English must take the **SPEAK** test and pass the examination at the required level in order to be appointed as a TA. Students must have a score of at least 50 or waiver approval following an interview to satisfy the SPEAK test requirement.

International students with a teaching assistantship are **required to attend** the International Teaching Assistant Orientation offered by the Graduate School.

Decisions on TA appointments are made by the Director of Graduate Studies. Students will be informed by the end of March whether they will have a TA position for the following academic year, subject to continued satisfactory progress in their Ph.D. program, subject to continued adequate performance of their TA duties, and subject to the budgetary considerations.

Important factors in making these decisions are:

- Progress through the core PhD program coursework and cognate courses.
- Professional and courteous performance of TA duties.
- Identifying research opportunities and making adequate progress towards their degree.

11.2 Research Assistantships

Decisions on RA appointments are made by individual faculty or by faculty groups involved in group research projects. Students will be informed by the end of March whether they

[3]Adapted with permission from the MSU Department of Physics & Astronomy Handbook for Graduate Students, Section XIV

will receive an RA for the following academic year (or whether their RA will be continued for the following academic year), subject to satisfactory performance of their RA duties and subject to the budgetary considerations.

Students should seek an advisor with a RA opening before the end of their second year in the program.

11.3 Missed work

In this section, "missed work" refers to work missed due to any reason, including (but not limited to) illness, injury, pregnancy, or dereliction of duty. Policies regarding missed work are governed by Article 12. iv-v and Article 18 of the GEU contract and, for students not covered by the GEU contract, the University's GA Illness, Injury, and Pregnancy Leave policy. Note that missed work due to illness, injury, or pregnancy are subject to a very different set of policies than missed work due to unsatisfactory performance – please consult the documents listed above for more information.

11.4 Outside work for pay

Graduate students who are appointed as a TA or an RA are expected to devote their time to their academic studies and to their TA/RA responsibilities. No outside work for pay can be undertaken without discussing with Director of Graduate Studies (in the case of TAs) or with their research advisors (in the case of RAs).

11.5 Tutoring

Tutoring can be of tremendous benefit to you as a student, both intellectually and financially. It can help you gain a better understanding of your field, and also help you to improve your teaching skills. It is critical, however, that tutoring not interfere with your coursework and with your assistantship. As such, you should discuss the decision to tutor with your academic and/or research advisor. Furthermore, tutoring should not exceed an average of 5 hours of your time per week.

If you are a teaching assistant, you **may not** receive compensation to tutor students enrolled in the course you are assigned to. Helping students in all sections of the course counts as a part of your duties, whether it occurs through office hours, direct contact in class, or in less formal settings. Asking for pay would constitute a conflict of interest because you are already being paid by the Department to provide these services for that particular course. You may, however, act as a paid tutor for any course to which you are **not** assigned as a TA in any given semester once you have received permission from your academic and/or research advisor.

12 University resources

12.1 University-level policy documents

MSU Academic Programs

MSU Graduate Students Rights and Responsibilities (GSRR) document

MSU/Graduate Employee Union Contract

Guidelines for Graduate Student Advising and Mentoring Relationships

Guidelines for Integrity in Research and Creative Activities

Policy on Relationship Violence and Sexual Misconduct

Anti-Discrimination Policy (ADP) User's Manual

MSU Graduate School Individual Development Plan

12.2 Other resources

College of Engineering graduate student information

Office of the Ombudsperson

Human Research Protection Program

PhD Career Services

Certification in College Teaching Program