Two-Semester Research or Thesis Option in the Master of Science in Applied and Computational Mathematics and the Post-Master's Certificate in Applied and Computational Mathematics

(https://ep.jhu.edu/current-students/student-forms/**)**

Background

The Applied and Computational Mathematics (ACM) Program emphasizes mathematical and computational techniques of fundamental importance and practical relevance. As such, ACM offers students the opportunity to do in-depth research that is meant to lead to an improvement of practice in industry, government, or non-profit organizations. To that end, this document describes the procedures and requirements for a student to pursue a two-semester research project through one of two different paths, the research option or thesis option.

The discussion below summarizes the requirements that students and faculty are to follow relative to the research and thesis options. Sections 1 – 3 summarize the requirements as they apply to either an M.S. degree or Post-Master's Certificate. Section 4 spells out the step-by-step procedure to be followed by students and research advisers. Section 5 is the list of ACM faculty approved to serve as research supervisors (a subset of the full ACM faculty). The Appendix gives the catalog descriptions for the research and thesis courses.

1. Requirements for the M.S. in Applied and Computational Mathematics

The requirements for the Master of Science in Applied and Computational Mathematics are as follows:

- Ten courses must be completed within five years.
  - Four core courses:
    - → 625.603 Statistical Methods and Data Analysis
    - → 625.601 Real Analysis *or* 625.609 Matrix Theory
    - → One 2-course sequence from the following options:
      - ⇒ 625.717 Advanced Differential Equations: Partial Differential Equations *and* 625.718 Advanced Differential Equations: Nonlinear Differential Equations and Dynamical Systems
      - ⇒ 625.721 Probability and Stochastic Processes I *and* 625.722 Probability and Stochastic Processes II
      - ⇒ 625.725 Theory of Statistics I *and* 625.726 Theory of Statistics
  - Six electives that must include at least four from the program (625.xxx), with at least two of the four courses at the 700-level. Students are required to take at least one 700-level course outside of the core sequences (625.717/718, 625.721/722, and 625.725/726).

If the student pursues a research or thesis option, the following two-course sequence may replace two of the six elective courses (either 600- or 700-level) outside of the four core courses:

- 625.801-802 Applied and Computational Mathematics Master's Research
  or
- 625.803-804 Applied and Computational Mathematics Master's Thesis

2. Requirements for the Post-Master's Certificate in Applied and Computational Mathematics

The requirements for the Post-Master's Certificate in Applied and Computational Mathematics are as follows:

- Six courses must be completed within three years.
- At least four of the six courses must be from the Applied and Computational Mathematics program (numbered 625.680 or higher).
- At least three of the courses must be at the 700-level, and at least one of the 700-level courses must be outside of the sequences 625.717/718, 625.721/722, and 625.725/726.

With a research or thesis option, the following two-course sequence may replace two of the required six courses (at either the 600- or 700-level):

- 625.805–806 Applied and Computational Mathematics Post-Master's Research
  or
- 625.807–808 Applied and Computational Mathematics Post-Master's Thesis

3. Research Requirements and Final Deliverable

It is required that the research be applied or theoretical work that goes beyond a straightforward implementation of known methods. It is also required that the research have significant mathematical content. The intent of the research is to expand the body of knowledge in the broad area of applied mathematics. Regardless of the option chosen (research option or thesis option), each project is to be guided by a research adviser, chosen from a subset of the ACM faculty called the ACM Research Faculty below (the research adviser may be different from the student's academic adviser assigned at admission to the ACM Program). In addition, each student is required to select a second reader to provide an independent second opinion on the research and the associated documentation. The second reader may be any member of the technical community (Johns Hopkins or elsewhere) who has deep knowledge in the area of the research.

The final deliverable is to be one of the following documents, depending on the option (research or thesis) chosen:

1. **Research option.** A technical paper on the order of 25 or more double-spaced typed pages (or equivalent) submitted to a peer-reviewed (refereed) journal or to a conference with accompanying refereed proceedings. It is also desirable, although not required, that the paper be presented at an external professional meeting if the primary submission is a journal article. See additional requirements for the final deliverable below.
2. **Thesis option.** An electronic thesis submission to the MSE Library following standards posted at http://guides.library.jhu.edu/etd. See additional requirements for the final deliverable below.

- Regardless of the option chosen, a professional-quality research or thesis defense presentation is required. The defense is to be scheduled near the end of the project, but prior to the assignment of the final grade. The presentation must be open to the public and the audience must include the adviser and second reader.
- For the research option, where the final deliverable is a journal-quality technical paper, if there are multiple authors, the student must be the primary contributor to the work of the paper (i.e., the student's work must represent *at least* 60 percent in both the technical content and the writing).

4. Research Proposal Process

Students and research advisers are to follow the steps below. (The form to accompany steps 1 to 5 may be found online at https://ep.jhu.edu/current-students/student-forms/)

1. The student contacts a potential research adviser from within the *ACM Research Faculty* below. The student may approach the adviser with either a project in mind or with the intention of soliciting suggestions for a topic from the adviser.
2. After choosing a topic, the student selects a second reader to provide an independent second opinion on the research and the associated documentation. The second reader is expected to be available for consultation throughout the duration of the research work and is expected to read and comment on the draft documentation produced near the end of the project. The second reader must be approved by the research or thesis adviser, academic adviser, and ACM Program Chair.
3. After settling on a research adviser, second reader, and a potential topic, the student conducts a thorough literature survey to identify related work and to clarify precisely what is known and not known about the potential area of study. The goal is to identify topics that would be new or add to the volume of knowledge and understanding in the areas of applied mathematics and modern computational methods.

4. After settling on a topic of study, the student writes a research proposal of approximately two-to-three pages. The proposal must identify both the research adviser and second reader. The proposal must clearly discuss the problem motivation, what the student intends to accomplish, and why the research will be an original contribution to the field using knowledge gained from the literature survey in step 3 above. The proposal is to also discuss the plans for final documentation; i.e., which option will be chosen, including the intended refereed journal and/or refereed conference proceedings for dissemination of the final results if the research option is selected. The discussion of documentation should also include mention of likely co-authors (if any) beyond the student and his/her adviser.
5. The research adviser and second reader endorse the proposal and forward it to the academic adviser for approval, who then forwards the proposal to the Program Chair for final approval. After final approval, the proposal and communication chain of approvals are added to the student's academic file.
6. Given the approved proposal and registration in the appropriate course (625.801, 625.803, 625.805 or 625.807), the research plan in the proposal is implemented by the student with an expectation of at least biweekly contact with the research adviser. Registration in these courses cannot occur until the proposal is approved (step 5 above).
7. At the end of the first semester, the student provides a brief status report by email to the research adviser, second reader, academic adviser, and Program Chair. If there are unique challenges or problems, these should be mentioned as part of the status report. The status report should provide a clear indication of what needs to be done to ensure completion of the project by the end of the second semester. The research adviser will assign a grade for the first semester based, in part, on this status report.
8. Given success in the first semester, the student enrolls in 625.802, 625.804, 625.806 or 625.808, as appropriate, and continues the research. Ideally, a final defense and corresponding deliverable are to be completed by the end of the second semester. The defense is to be scheduled at a time and location of convenience to the student, research adviser, second reader, and others with an interest in the topic. The academic adviser and Program Chair should also be informed about the defense. The final deliverable must take account of relevant comments or questions that arise during the defense. Note: If the final deliverable has not been submitted to the appropriate outlet by the end of the second semester, the thesis adviser may assign an "I" [incomplete] grade until all conditions are met.
9. A final message that certifies the satisfactory completion of the defense presentation and the paper/thesis is sent by the research adviser and second reader and forwarded to the academic adviser and the Program Chair together with a copy of the final paper/thesis. If the final product includes authors other than the student, the adviser must discuss the student's role relative to that of the other authors; the final message must certify that the student is the primary contributor (over 50 percent) to both the technical work and the writing of the paper/thesis. For the

thesis option, guidelines at http://guides.library.jhu.edu/etd are to be followed. The Program Chair gives the final approval and the research adviser then assigns the final grade to the relevant course (625.802, 625.804, 625.806 or 625.808). The approval message from the Chair to the research adviser and the final paper/thesis are placed in the student's academic file and, as appropriate, sent to the MSE Library. If the research adviser assigned an "I" grade for reasons discussed in item 8 above, the submission of the approved checklist and final paper/thesis for the student's academic file should be delayed until the adviser is ready to assign a final letter grade.

5. ACM Research Faculty

The following ACM faculty members are available to supervise two-semester research or thesis projects.

Name	Contact info. (email and/or phone and/or personal website)	Courses taught in ACM	Areas of specialization	Comments
Beryl Castello	beryl.castello@jhu.edu	625.615, 625.741, 625.616 (and other courses in JHU AMS Dept.)	Optimization of facility location; deterministic optimization.	Student expected to take course from instructor prior to research.
Cleon Davis	cleon.davis@jhu.edu	625.201, 625.690	Intelligent systems (neural networks, genetic algorithms, fuzzy logic).	--
Mark Fleischer	markfleischer@alum.mit.edu	625.638	Probabilistic Optimization, Multiobjective Optimization	Would prefer student to have taken at least one 700-level course.
Stacy Hill	stacy.hill@jhuapl.edu	625.601, 625.728, 625.744	Stochastic estimation; modeling and optimization.	Student is expected to have taken at least one 700-level course from instructor.
Anthony Johnson	ajohn260@jhu.edu	625.250, 625.251	Numerical ODEs; PDEs; FEA; complex variable boundary element method.	--
Nandi Leslie	nandi.o.leslie@gmail.com	625.644	Machine learning, statistics, stochastic processes, cybersecurity	

Name	Contact info. (email and/or phone and/or personal website)	Courses taught in ACM	Areas of specialization	Comments
Christine Nickel	Nickellc@aol.com; 703-732-6824	625.734, 625.664, 625.680	Probability and discrete mathematics.	Student expected to take course from instructor prior to research.
Moustapha Pemy	mpemy@towson.edu; 410 704 3585; https://tigerweb.towson.edu/mpemy/index.html	625.695, 625.641, 625.642	Stochastic control and mathematical finance.	Student expected to take course from instructor prior to research.
Burhan Sadiq	burhan.sadiq@jhuapl.edu	625.603	Numerical Analysis, Approximation Theory, Modeling & Optimization, Machine Learning, Data Mining.	Student expected to take course from instructor prior to research.
Cetin Savkli	cetin.savkli@jhuapl.edu	625.603 (Also teaching Graph Analytics 605.632 under CS Program)	Graph analysis; data mining; probabilistic models; multivariate time series analysis.	Exposure to graph algorithms, probability and statistics; competence in a programming language (such as Java or Python).
David Schug	david.schug@navy.mil or david.schug@gmail.com	625.603, 625.604	Numerical Methods, Math Modeling, Harmonic Analysis, Wavelet Theory, Signal Processing, Bayesian Estimation/Kalman filtering, and Data Analysis applied to remote sensing, image processing, computer vision and photogrammetric methods.	--
Tatyana Sorokina	tsorokina@towson.edu; https://tigerweb.towson.edu/tsorokin	625.611, 625.687	Numerical analysis; approximation theory; multivariate splines; finite elements.	--

Name	Contact info. (email and/or phone and/or personal website)	Courses taught in ACM	Areas of specialization	Comments
James Spall	james.spall@jhuapl.edu; http://www.ams.jhu.edu/~spall/Personal/index.htm	625.743 (plus other courses in JHU AMS Dept. within full-time programs)	Stochastic systems and estimation; optimization; Monte Carlo methods.	Student expected to take course from instructor prior to research.
Mike Weisman	mjw@jhu.edu; 240-228-3784	625.703, 625.740	Data mining; machine learning; computer vision; complex analysis; dynamical systems.	Student is expected to have taken at least one 700-level course from instructor.
Tom Woolf	tbw.jhmi@gmail.com	625.260, 625.609, 625.620, 625.692, 625.714, 625.721–722	Stochastic processes, time-series analysis, machine learning, database systems, and graphical systems.	Student expected to take course from instructor prior to research.

Appendix

Below are catalog descriptions for the research and thesis courses. Students pursuing the research or thesis options for either an M.S. degree or Post-Master's Certificate are required to register for these courses. The relevant sequence below may be used to fulfill two courses within the 700-level course requirements for the ACM M.S. degree or Post-Master's Certificate.

625.801–802 Applied and Computational Mathematics Master's Research
625.803–804 Applied and Computational Mathematics Master's Thesis

The course sequences 625.801–802 and 625.803–804 are designed for students in the ACM Master's program wishing to work with a faculty adviser to conduct significant independent original research in the field of applied and computational mathematics (each of 625.801, 802, 803, and 804 is one semester). A sequence may be used to fulfill two courses within the 700-level course requirements for the ACM M.S. degree; only one sequence may count towards the M.S. For sequence 625.801–802, the student is to produce a technical paper for submission to a journal or to a conference with accompanied refereed proceedings. For sequence 625.803–804, the student is to produce a bound hard-copy thesis for submission to the JHU Library and an electronic version of the thesis based on standards posted at http://guides.library.jhu.edu/etd (the student is also encourage to write a technical paper for publication based on the thesis). For either sequence, the intent of the research is to expand the body of knowledge in the broad area of applied mathematics, with the research leading to professional-quality documentation. Students with a potential interest in pursuing a

doctoral degree at JHU or another university should consider enrolling in one of these sequences to gain familiarity with the research process (doctoral intentions at JHU or elsewhere, however, are not a requirement for enrollment). Note: The student must identify a potential research adviser from within the ACM Research Faculty to initiate the approval procedure *prior* to enrollment in the chosen course sequence; enrollment may only occur after approval.

Prerequisites: Have completed *at least* six courses towards the M.S., including the ACM courses 625.601 (Real analysis) and/or 625.609 (Matrix theory), 625.603 (Statistical methods and data analysis), and at least one of the following three ACM two-semester offerings: 625.717–718 (Advanced differential equations: Partial differential equations and nonlinear differential equations and dynamical systems), 625.721–722 (Probability and stochastic processes I and II), or 625.725–726 (Theory of statistics I and II). It is recommended that the research or thesis sequence represent the final two (9th and 10th) courses of the M.S. degree.

Instructor: Member of ACM Research Faculty.

625.805–806 Applied and Computational Mathematics Post-Master's Research
625.807–808 Applied and Computational Mathematics Post-Master's Thesis

The course sequences 625.805–806 and 625.807–808 are designed for students in the ACM Post-Master's certificate (PMC) program wishing to work with a faculty adviser to conduct significant independent original research in the field of applied and computational mathematics (each of 625.805, 806, 807, and 808 is one semester). A sequence may be used to fulfill two courses within the course requirements for the ACM PMC; only one sequence may count towards the PMC. For sequence 625.805–806, the student is to produce a technical paper for submission to a journal or to a conference with accompanied refereed proceedings. For sequence 625.807–808, the student is to produce a bound hard-copy thesis for submission to the JHU Library and an electronic version of the thesis based on standards posted at http://guides.library.jhu.edu/etd (the student is also encourage to write a technical paper for publication based on the thesis). For either sequence, the intent of the research is to expand the body of knowledge in the broad area of applied mathematics, with the research leading to professional-quality documentation. Students with a potential interest in pursuing a doctoral degree at JHU or another university should consider enrolling in one of these sequences to gain familiarity with the research process (doctoral intentions are not a requirement for enrollment). Note: The student must identify a potential research adviser from within the ACM Research Faculty to initiate the approval procedure *prior* to enrollment in the chosen course sequence; enrollment may only occur after approval.

Prerequisites: At least three courses (four recommended) towards the Post-Master's Certificate. It is recommended that the research or thesis sequence represent the final two (5th and 6th) courses of the ACM Post-Master's Certificate program.

Instructor: Member of ACM Research Faculty.