

Program Review Report

Applied Mathematics Department  
University of Washington  
Seattle, Washington

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Review Committee:

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## Executive Summary

The Department of Applied Mathematics at the University of Washington in Seattle has an excellent reputation among Applied Mathematics Departments. The Department has benefited from excellent leadership from a succession of outstanding chairs and from the quality and collegiality of their senior faculty. The faculty are productive in research and the PhD students have a record of success. The Department is a leader in providing online applied mathematics instruction, and has instituted a highly successful fee-based MS program in Computational Finance and Risk Management (CFRM). The department faces several challenges. They need to rebuild leadership in numerical/computational mathematics in view of the retirement of key faculty in this important area. They need to continue to increase the diversity of their faculty and students. They need to increase the number of women and minority faculty to better represent the US population. They need to seriously consider establishing a successful undergraduate major in applied mathematics that they can grow to a reasonable size to provide student access to STEM careers and to gain access to funding for the Department that is tied to undergraduate teaching and majors, while maintaining their contribution to the ACMS undergraduate program. To do this, they will need additional advising staff and may need to consider how to balance their teaching commitments. Space and facilities are adequate for faculty, but less so for online-enabled classrooms, and the building is not ADA compliant and has serious seismic deficiencies.

### 1. Are they doing what they should be doing?

**Program Focus and Strategic Direction:** The focus of the Department of Applied Mathematics (AMath) is to apply mathematics to solve real world problems and to create new methods and theory in order to address and understand a range of mathematical applications. In the early days of the unit, many applications centered around fluid dynamics with an emphasis on mathematical problems that arise in aeronautical engineering, atmospheric and oceanographic sciences. Application areas have significantly expanded to include mathematical biology, data science, financial mathematics, nonlinear dynamics and waves and others. The faculty have substantial expertise in the methodology underlying these application areas including computational/numerical mathematics, analysis of ordinary and partial differential equations, applied probability, stochastic analysis and optimization. While not all areas of applied mathematics are, nor can be, represented by the department, the above areas are considered centrally important by most applied math departments and programs in the US.

Areas that the unit plans to focus on in the upcoming years are computational math/scientific computing, data sciences, applied probability and stochastic analysis. AMath has significant strength in these fields on which to build. AMath expressed serious concern about the age distribution of its faculty with a number either retiring or approaching retirement age. Not

replacing these retirements could seriously impact the future direction of the unit. The department members are particularly worried that retirements would put at risk the department's leadership position in numerics/scientific computing.

**Educational Programs:** The Applied Mathematics Department has demonstrated innovative graduate training, with cutting edge novel programs, including CFRM, stochastics & probability, data science, all strategic areas in which demand is rapidly growing. These efforts should be rewarded by the university, as they hold great promise for strengthening of the Seattle, Washington State, and the Pacific Northwest-based industrial and financial sectors. Details follow:

**PhD Program:** At the core of the program is the research PhD training. The Self-Study Report documents that this program turns out excellent, highly qualified personnel, many of whom go on to leadership roles in academic and/or industry positions.

**Fee-Based Masters Degrees:** The AMath faculty have been extremely successful in designing and executing two innovative fee-based MS programs, including the Computational Finance and Risk Management MS (CFRM) and the on-campus and parallel online AMath MS. The committee met with students and faculty involved in these programs, and we were highly impressed by several features: (a) The courses in CFRM are innovative for UW, and in a short time, have placed the program close to the top 10 in North America, in competition with heavy-hitters such as Columbia, Princeton, Harvard, and other long-standing finance programs. (b) Students in the program recognize the value they get. With the intense mentoring and professional development guidance in the program, graduates are nearly all placed in well-paying jobs in the financial sector. (c) The program emphasizes an excellent student experience. (d) The MS programs are fee-based, self-sustaining, and generate significant revenue for the department and the College. The program also addresses a huge demand for training in the financial mathematics sector.

**Online Instruction:** The AMath MS includes both an online component, and parallel on-campus offerings, with shared lectures that are streamed and recorded for later viewing. The flexibility of the online MS is a great boon to students currently employed, and the flexibility built into the program is greatly appreciated by such students. The program for regular on-campus MS students could be aided in several ways by a minor investment: (a) by renovating the MS space and/or developing new space (see below under "Facilities") to accommodate MS students in the department, so that they are more closely integrated into the Applied Mathematics community at UW. (b) By adding to the support for advisors and/or career counselor(s) dedicated to guiding MS students (over and beyond the CFRM MS.) Here, a small investment by the College could go a long way in solidifying the career prospects of the general on-campus MS graduates.

**Undergraduate Teaching:** AMath participates in undergraduate teaching in the Applied and Computational Mathematics Sciences (ACMS) with partner departments (Mathematics, Statistics, and Computer Science). This is a competitive major that currently has a cap of 200 students due to bottleneck courses that limit the capacity of the program. One such bottleneck is the Mathematical (Discrete) Modeling with a limit of 35 students stemming from the project requirement. Faculty in the ACMS admissions committee expressed frustration with having to turn away a huge number of excellent students, and felt that the program could (with support from the College) serve many more talented young people. However, to scale up from 200 to (say) 300 majors would require investments in TA support for the partner departments, to alleviate the bottlenecks and maintain the excellence of the program.

The committee also noted the following issues: The ACMS majors are currently “homeless” in that they do not feel a sense of belonging to any department. The committee recommended several measures to address this issue: (I) In the short-term, and with minimal incremental cost, AMath could offer a number of social events (“Pizza lunches/seminars” or similar networking opportunities) to bring the students into the department and to expose them to interesting topics, career strategies, and a sense of shared community. (II) In the near term, AMath should seriously consider introducing a new Applied Mathematics undergraduate major, tailored to the evolving and ongoing developments in the field. The committee recommends this option for several reasons: First, because it would naturally meet the growing demand for training in this area not currently met by ACMS. Such growth could support the local industry base of Seattle and Washington State, and generate alumni who are invested in the future of the university. Second, it would complement (rather than compete) with ACMS as a versatile and flexible program that could more easily be molded to evolving job market opportunities; and third, it would increase the participation of AMath faculty in tuition-based undergraduate instruction at UW, contributing additional tuition funding to AMath.

The committee recognizes that developing such a new AMath major would imply cost in terms of faculty time and energy, TA resources, and administrative burden. The committee strongly recommends that the College provide initial assistance to the department in terms of TA and administrative salary support to kickstart such a new majors program. Based on the track record of AMath in responding to educational challenges, the committee has no doubt of the success of such a Majors Program.

The committee also recommends consideration be made of combining a BS and MS in AMath, preparing students for graduate school.

## 2. Are they doing it well?

**Quality of Faculty and Research Program:** The Applied Mathematics Department at UW is a world-renowned, internationally recognized department, among the top in North America in terms of research leadership, training, and accomplishment. Historically, the department was founded on methods of classical Applied Mathematics, as well as fluid mechanics. The department has been recognized internationally for its excellence in numerical methods, with a number of stellar faculty (see below for upcoming retirements). In recent decades, the department has responded with agility and innovation to emerging areas of Applied Mathematics. Among these are Mathematical Biology, in which Amath has recognized strength, including both senior, mid-career, and newly hired faculty. In the last few years, the department has developed new programs in Stochastics and Probability, as well as Computational Finance. In the latter area, developments have been made in research, teaching, and certificate-programs.

**Quality of educational programs:** The quality of the AMath educational programs is very high. The undergraduate (UG) ACMS major has limit of 200 students. The faculty who reviewed the applications noted, with sadness, how many excellent students had to be turned away. The PhD program is very strong. In 2017 there were 285 applicants, of which 31 were admitted and 13 accepted the offers and were enrolled. In 2018 there have been 400 applicants with 24 admissions; 10 acceptances are expected. The PhD program is extremely selective; it competes with the top PhD programs in the US. The MS programs address distinct aims of certification and enrichment of students, rather than focusing on research, and while not at the same level of quality as the PhD program, are nevertheless very good. The CFRM MS program is already ranked 14 in the US even though it only began in 2011.

**Quality of students:** AMath attracts excellent students into its PhD, MS and CFRM graduate programs.

**Diversity:** The Department appears to be making a good effort to recruit holistically in order to attract underrepresented groups such as women and minorities into the graduate program. Women represent nearly 50% of the graduate student population. Other underrepresented groups have been more difficult to recruit, but the department does make an effort to reach out to HBCUs with some success. Currently there are only two female faculty, one full and one assistant professor. The department needs to be proactive in recruiting and retaining more female and minority faculty. The Department appears to be a place where individuals and their differences are respected, and we saw evidence that the department is welcoming to all.

**Finances and Facilities:** AMath has done very well with its fee-based MS programs and has also attracted major external funding for research. This income supplements monies provided from the College. The Department has moved into refurbished Lewis Hall in which there is

presently adequate office space and conference rooms, but no classrooms. Additional space could be well used. The space currently available to MS students could be updated. The building is not ADA compliant, except on the ground floor, as it has no elevator. The building is likely to suffer significant damage in a major earthquake, as it is unreinforced brick construction. A large attic space in Lewis Hall could be made into usable and attractive space. The department is willing to contribute financially to help such a project.

**Strategic direction:** The unit concentrates on a number of key areas in applied mathematics including: computational math, mathematical biology, data science, stochastic process, financial math, nonlinear dynamics and waves. Amath's strategic directions are consistent with maintaining excellence in these fields. The unit is exploring mechanisms to continue to enhance its position within the university in data science. One new faculty line was added via the Provost's Initiative in Data Science. Retirements are an issue; two computational/numerical mathematicians will retire by the end of summer 2018. Properly replacing these retired faculty is of great importance and failing to do so could seriously impact the future direction of the unit.

### **3. How can they do things better?**

**Diversity:** AMath has assembled an active and effective Diversity Committee to address issues of diversity recruitment (in both faculty and student streams). The committee was impressed with efforts made to review graduate applications in a more holistic way and in the recent hiring of a junior woman faculty member. At the same time, AMath currently has only 2 women faculty, one of whom is nearing retirement. Consequently, we have a number of recommendations for possible steps to improve the effectiveness of recruitment: (1) To recruit excellent women faculty, AMath should actively seek excellent women applicants by personally contacting promising female candidates, seeking to hire exceptional female postdocs based on recommendations of colleagues elsewhere, and encouraging outstanding women to apply. Personal encouragement goes far in enriching the applicant pool with larger numbers of talented women. The same should be done to recruit faculty from minority groups that are not currently represented in the faculty. (2) Minority students with gaps in their backgrounds could be offered an incoming "boot-camp" to prepare them for the program. (3) NSF has programs that fund opportunities for minority and diversity in training. Such programs could help to increase the number of graduate students from under-represented segments of the population. (4) NSF grant proposals have mandatory sections on "Broader Impact". Faculty in AMath who are renewing their NSF grants would benefit by being involved in such efforts to recruit, accommodate, and train a diverse pool of graduate students. (5) Many conferences (such as SIAM, AMS, CAIMS, SMB) have sessions for minorities and for undergraduate student researchers. AMath faculty and students who travel to such conferences could be subsidized by partial travel fund support to recruit promising women and minority students to AMath at UW.

**Student Advising:** As mentioned earlier, the ACMS Program is extremely good. But it appears to be hampered by the way that the program is administered as a joint effort amongst Computer Science, Statistics, Math and AMath. As opposed to BS majors connected to a particular unit, there seems to be no direct College support for advising of these interdisciplinary ACMS undergraduates. Currently, a Mathematics department advisor takes care of most advising of the ACMS undergraduates, apparently as an overload. The review committee met with undergraduates who stated that many of them felt they were not centrally part of any particular unit. In addition, the ACMS students weren't sure how to make their complaints heard to anyone who could make the desired improvements. They also said that numerous courses repeated the same material (e.g. MATLAB) over a few weeks at the beginning of the semester. A separate major with an Amath advisor could help address these issues. The PhD program seems to have an adequate advising system. The CFRM MS program's faculty are extremely engaged; they have a dedicated person involved in career counselling and placement of its students. Since CFRM students are highly motivated to obtain employment after graduation, having a staff member helping them find employment is an essential aspect of the success of this program. The CFRM students expressed satisfaction with the advising they receive. The AMath MS program serves many currently employed students seeking to pick up new mathematical skills, and consequently, there is less directed guidance towards job placement. While limited MS advising exists, it is not at a level comparable to advising in the PhD and CFRM programs. Students in the Applied Mathematics MS program, a one-year non-thesis MS degree, felt that additional career and academic advising would be desirable.

#### **4. How should the University assist them?**

**Faculty recruitment:** Recent and upcoming retirements of key leadership faculty members in numerical analysis (including Prof. Martin, as well as Prof. LeVesque, Todorov, and Greenbaum in future) threaten the leadership reputation of the department in this vital aspect of Applied Mathematics. There is **urgent need to hire new faculty to fill these leadership roles**. Neglecting this issue, or delaying the advertising leads to the possibility that the department would lose momentum, and give up its internationally recognized position at the forefront of this important area.

**Advising Services:** Advising services for undergraduates are provided for the ACMS students by the undergraduate advisor in Mathematics, Sarah Garner, as an add-on to her mathematics advising duties. If this program is expanded, and/or the Applied Mathematics Department establishes an undergraduate major, then additional advising staff for the undergraduates in these programs will be needed.

**ACMS:** The AMath department has taken a leadership role in the ACMS undergraduate major. This is an interdisciplinary effort among four departments: AMath, Computer Science, Math and Statistics. Enrollment in this major is limited to 200 students and apparently many more wish to matriculate. The Mathematics department advisor has taken on additional advising responsibilities, but the students in ACMS still feel left out.

**AMath Undergraduate Major:** The AMath department and the College of Arts and Sciences (CAS) should work together to enable a dedicated BS major in Applied Math in addition to the interdisciplinary ACMS major. The College should support an undergraduate advisor who would concentrate on both the ACMS and the new AMath BS major. The major could use or adapt many existing courses. The College and AMath should discuss the importance of undergraduate programs which, according to the CAS Associate Dean of Natural Sciences, is the central mechanism of support for the college. A five-year BS-MS program could be a natural outgrowth of the new major and/or a new track within ACMS.

**TA Support:** AMath has used some of its fee-based instructional revenue to pay TAs who support tuition-based courses. These TAs do not receive tuition waivers as do TAs who are supported from tuition revenue to support tuition-based courses. Thus AMath has to provide both salary and tuition for these TAs. The committee recommends that this situation be remedied.

**Space and facilities:** The deficiencies of Lewis Hall in ADA compliance and seismic safety have already been mentioned. An elevator and a seismic upgrade are needed improvements. The success of AMath in their teaching mission (and especially in the online offerings) is hampered by constraints on access to suitable classroom space. With suitable space, the online MSc programs could be significantly increased in size, bringing in additional revenues. The Department, the College and the University could benefit from more classrooms that are properly equipped for remote learning. Renovation of the first floor MS student area, or making the attic space of Lewis useable as has been done for Clark Hall would be a very effective way of addressing a number of these issues at once.