Computational Mechanics and Optimization Laboratory
Advice, Expectations, and Resources[1]

I firmly believe my graduate students, postdoctoral scholars, and research associates are my greatest resources for impactful, productive research and I hope to be your greatest professional resource. Therefore, success in our respective careers is deeply intertwined, which bestows upon both parties a commitment and responsibility that should not be taken lightly. This document details the expectations I have for all researchers, including myself, working in the Computational Mechanics and Optimization Laboratory (CaMOLab), lab policies, and advice for success during your time in the CaMOLab and into your professional career.

Advice for research personnel[2]

- **Success is determined by you**: I can only set up an opportunity for research and provide feedback along the way. What you do with it is primarily up to you. You shouldn't expect me to tell you what to do from the beginning to the end of your studies. After a certain point, the ideas, the implementations, the papers, and the success will be mostly because of your talent and hard work.

- **Learn on your own**: The development of numerical methods is a huge, fast-moving field and, as such, you shouldn't expect me to know everything. Read and learn on your own. Attend seminars and conferences, talk with your colleagues (students, postdocs, or professors), read papers, follow references. Once you know a few new things about a topic, teach me and your CaMOLab colleagues about it.

- **Show initiative**: There are many people who can execute a task once they are told exactly what to do. The ones that really excel are those who are active participants in a research group, e.g., ask questions, offer replies, suggest new problems to work on, come up with innovative solutions to problems, spend extra time trying to analyze and verify the results. So, don't sit back and wait to be told what to do. Be active. Every now and then you may ask a "stupid" question or suggest a "bad" idea. This is a natural part of the learning process. And don't be intimidated by the intelligence of the faculty or other students.

- **Be broad**: Students often tend to rush to overspecialize on a niche research domain. While this may seem the fastest way to get results, you should try to resist the temptation. The importance of your research topic and the impact of your thesis will be much higher if you have a broad understanding of the field. This applies to your coursework, the seminars you attend, and discussions with other researchers.

- **Be organized**: Organize your work to achieve short-term (daily, weekly) and long-term (monthly, yearly) goals. Your time is a very valuable commodity. Use it in a smart way. In addition, keep good notes of the ideas, issues, and bugs you encounter. This is the best way to avoid duplicating work and to have a head start on all papers, reports, etc.

- **Be honest about your work**: The worst thing you can do is to ruin your reputation. Be honest when you promise to deliver something (result, paper, etc). Be honest when you present your research accomplishments. It is easy to be dishonest with both and get away with it in the short term. However, your advisor and colleagues will eventually catch up with you and, once your reputation is damaged, it is very difficult to recover.

- **Find original, interesting, important project**: It is important that each person in the CaMOLab finds a project that is original, interesting, and important. In addition, it should complement other projects in the lab and align with the overall direction of the CaMOLab and its funding. Perhaps most importantly, the project should align with your interests and skills and group members are encouraged to take (at least partial) ownership of their project. That is, you should actively try to contribute to the overall direction of the project instead of solely crunching through the technical details. Consider the application areas where our methods could make an impact, weaknesses of the methods that should be addressed, etc. Only when a researcher feels ownership of a project will they truly be invested in it

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[1]Adapted from a number of resources, including John Boothroyd, Christos Kozyrakis
[2]Content of this section is mostly taken from http://csl.stanford.edu/~christos/new_students.html.

and work hard to see it become successful. Since I fund every member of CaMOLab, I will primarily be responsible for proposing projects that are original, interesting, and important. However, we must work together to match you with the appropriate project based on your interests and skills.

Work ethic and schedule

I expect group members to be self-motivated and driven. While the required research hours per week are moderate (20 hours for students, 40 hours for full-time research personnel), the nature of our research projects often require more to ensure sufficient progress is being made. However, the number of hours worked is not what is important; what matters is productivity while working and research progress. I will never question a researcher's work hours or ethic if they are making exceptional progress on their project. In cases where research productivity is not sufficient, I will work with you to develop a more productive research environment and structured work schedule. Finally, an enormous benefit of the academic lifestyle is the flexible schedule it affords; however, I do request group members be present in lab a few hours during a standard work week to benefit from the collaborative environment.

That being said, I encourage all members of my group to love what you do and take ownership of and responsibility for your project. By becoming invested in your research and success of the project, you will find yourself extremely motivated to work hard and ensure the project proceeds on or ahead of schedule. While I do not require that any of my research personnel work during the evenings or on the weekends, I personally have found these practices to be an excellent way to get ahead. In particular, I built my research software during these times and launched new research projects and directions. This, of course, must be balanced with maintaining your health and personal life.

Lab environment

I expect the lab environment to be professional and inclusive. Senior lab members should be welcoming to new members and actively seek to assist or mentor them during their transition and beyond. I also want the lab environment to be collaborative with open exchange of ideas, research and technical discussions, etc. In order for all members to feel safe in discussing potentially novel, proprietary ideas, I will be proactive and transparent in dealing with issues pertaining to intellectual property and authorship. To avoid potential authorship conflicts, contributions that warrant authorship are clearly defined based on [1], authorship will be an ongoing conversation throughout the life of a project, and all authors on a manuscript will be required to complete and agree upon a *Statement of Authorship*; see section on **Research dissemination** for more detail.

Expectations of myself

Given the high expectations I have of my research team, it is only appropriate that I hold myself to even higher standards. I firmly believe that the best way to lead is by example and will strive to embody the expectations I have set forth in this document. I will do my best to provide you with technical and professional guidance that furthers your progress toward **your** professional goals. I will provide opportunities for conference travel and assist with networking and other scholarly activities that will advance your career and overall experience in the CaMOLab. In addition, I promise to: 1) immediately resolve any lab conflicts, 2) treat all equally, 3) be professional, 4) give credit where credit is due, particularly in public presentations, 5) not be the bottleneck in getting manuscripts submitted, and 6) be a life-long mentor to the extent you choose (I still turn to my thesis and postdoc advisors for guidance).

Performance reviews

At the end of each semester, every member of the CaMOLab must complete a performance review of themselves that I will comment on and expand upon. In addition, I will review myself as an advisor and lab director and seek feedback from each lab member. I will meet with each person individually to discuss our reviews, celebrate our successes, and identify our weaknesses and develop a strategy to address them. These reviews will also help us keep our respective CVs up-to-date, a very challenging but important task, and help me write a strong, comprehensive letter of recommendation for you when the time comes.

Successful completion of appointment in CaMOLab

Prior to your departure from the CaMOLab, you must incorporate the methods you developed into the appropriate lab code (CaMO codes, autogen, pytikz, etc) and provide documentation and unit tests that

adhere to the standards of the code. In most cases, this involves an efficient, well-designed, scalable implementation in C++/MPI. However, in projects with significant theoretical work/impact, a well-tested and documented prototype implementation in Python or MATLAB may be sufficient.

This ensures your methods can be used for comparisons and as the foundation of future methods, which benefits you (generates citations and visibility for your work) and supports the continued prosperity of the CaMOLab. Due to the importance I place on cleanly incorporating your methods into lab codes, I will only sign your thesis (Ph.D. students) or write letters of recommendation once this has been done or, at least, is progressing toward completion. Finally, I ask that prior to departing from lab, we brainstorm future directions for your topic, particularly if you intend to leave academia or change topics.

Meetings

Lab meetings

All members are expected to attend bi-weekly (every two weeks) CaMOLab meetings. At the beginning of each semester, I will find a time slot that accommodates everyone's schedule (make sure your calendar includes your class schedule and any known travel). In these meetings, group members will present research progress, a relevant paper, or research issues/questions and we will discuss/brainstorm the topic as a group. These group presentations are perfect opportunities to practice your presenting and communication skills for upcoming conferences or interviews. I will be critical (but polite) to help you improve your technical communication skills. Finally, there will be food (ranging from light refreshments and snacks to a full lunch, depending on the occasion) at some meetings. I will finance the food, but will recruit students to help me pick-up and arrange it.

Individual meetings

In addition to the group meetings, I will meet one-on-one with every group member at least bi-weekly (every two weeks) to ensure sufficient progress is being made, discuss difficulties or technical issues, and provide any advice or guidance you may need. Prior to our meeting, you are expected to push updates to your research slides (see Research journal) that summarize your research activity over the past two weeks and includes any research progress and milestones.

Unscheduled meetings

The bi-weekly lab and individual meets are the *minimum* I expect to meet with my students and postdocs. I also encourage you to meet with me outside these recurring meetings when you need advice, guidance, or technical assistance. You are welcome to drop by my office, but I encourage you to email me first to make sure I'm in my office and available.

Mentorship

I will be the primary mentor for all members of CaMOLab, regardless of seniority and duration in lab. I encourage all group members to meet with me as often as necessary (in addition to our bi-weekly one-on-one meetings) regarding career advice, guidance on research, technical assistance, questions regarding lab software, or other topics you would like to discuss. To maximize our productivity during our meetings, you should consult other members of CaMOLab first so we can focus on topics not easily answered by other CaMOLab members. Senior CaMOLab members are expected to provide advice and technical assistance to newer members, essentially "paying forward" the effort that was devoted to your development as a new group member. This leads to an efficient, close-knit, and fully functional group where all members contribute not only to research but to the sustained success of the group by investing in the development of its members.

PhD students

Timeline

I expect PhD students to take a heavy load of classes in their first year to quickly get up to speed so you can do productive research. If you are not doing research your first year, then you should take 4 courses; if you are doing research, then 3 courses is sufficient. In your second year and beyond, you are expected to transition to a heavier research load and lighter course load. Some important courses for first two years: Computational Fluid Dynamics (AME 50532) ◆ Finite Element Methods (AME 50541) ◆ Mathematical Methods I (AME 60611) ◆ Mathematical Methods II (AME 60612) ◆ Numerical Methods (AME 60614) ◆ Continuum Mechanics

(AME 60624) ◆ Intermediate Fluid Mechanics (AME 60635) ◆ Computational Nonlinear Solids (AME 60741) ◆ Advanced Scientific Computing (ACMS 60212) ◆ Numerical Linear Algebra (ACMS 60395) ◆ Numerical Methods I (ACMS 60690) ◆ Numerical Methods II (ACMS 60790)

Teaching

Every semester throughout your Ph.D., graduate students must devote three hours per week to assist the teaching of an AME course. This is a service you must provide to re-pay your first year fellowship and must be taken seriously. However, since teaching does not factor into your quest to obtain your Ph.D., it is critical not to spend too much time teaching, e.g., at least three hours per week but no more than five. Whenever possible, I will have my graduate students as teaching assistants (TAs) for my courses and will minimize your responsibilities to ensure research remains your top priority.

For students interested in a career in academia, teaching experience is crucial to securing a high-quality position. The teaching assistant experience you will gain as a graduate student will showcase your teaching abilities, particularly if you obtain positive course reviews; however, it does not give you the chance to design a course and be responsible for the lectures. Notre Dame allows graduate students and postdoctoral scholars the opportunity to be the principal instructor for a class (EG 10111, 10112: Introduction to Engineering Systems) through the First-Year Engineering Teaching Apprenticeship Program. This is a generous and unique opportunity to expand your teaching portfolio as more than a TA.

Graduation

A PhD will be awarded in my group for the introduction of a novel numerical method, or significant advancement of an existing method, to solve relevant and challenging problems that arise in mathematics, engineering, science, or medicine. This includes a thorough study of the method against the state-of-the-art, a parallel implementation in CaMOLab codes, and demonstration of the method on a large-scale example. In some cases, a PhD will be awarded for the application of a new or existing method to study or solve a real-world problem, usually done in collaboration with domain experts. This will almost always require extending the method to meet the needs of the particular application and therefore constitutes a hybrid project that involves method development and a scientific study in a particular domain.

PhDs in my group usually take 4 - 6 years, with 5 years being the most common. When you feel you have sufficient material to write and defend your thesis, we will meet to agree upon tasks and a timeline for the remainder of your PhD. Two *requirements* I have for all of my PhD students before I sign your thesis are: (1) at least 2-3 papers in top, peer-reviewed journals (conference papers, e.g., AIAA manuscripts, do not count) and (2) all of the conditions in the section entitled **Successful completion of appointment in CaMOLab**, i.e., implement, debug, unit test, and document your methods in CaMOLab codes. The actual number of papers required for graduation will depend on the scope, impact, and content of your papers. Finally, I hope you will attend the Notre Dame graduation ceremony so I have the honor to hood you.

Insufficient progress or dedication to CaMOLab

In the rare and unpleasant event that a group member fails to make sufficient progress on their project or refuses to fully integrate into the CaMOLab, e.g., participate in one-on-one and group meetings, complete recommended coursework to obtain the necessary background, spend the required hours in lab to benefit from lab environment, mentor new lab members, etc., a number of steps will be taken. First, every reasonable step will be taken to address the underlying problem, particularly if the struggles stem from insufficient background. However, if the underlying issue is an insufficient work ethic to meet the demands of the project and the CaMOLab, the researcher will likely be phased out of the group since this represents a mismatch in our expectations and passion for the work. In this case, undergraduate students will not be re-hired in subsequent semesters and postdoctoral scholars will not have their yearly contract renewed. Graduate students will either be transferred to another AME professor, conditional upon finding a professor with the interest and means to fund the student, or will graduate with a M.S. degree. In my biweekly meetings with each CaMOLab member, I will clearly identify issues that could eventually lead to dismissal to give ample opportunity to address the issues.

Scholarly duties

LITERATURE

It is your responsibility as a scholar to be aware of the research history and activity in your field. This means acquiring a solid understanding of the field through a detailed review of the literature *and* keeping this knowledge current by reading new papers in the field and attending talks at conferences. Solid and up-to-date knowledge of the state of your field is extremely important: (1) it can save you countless hours chasing down "new" ideas that have already been documented in the literature, (2) it will give you a solid foundation for the literature review needed to write your papers, particularly their introductions, and (3) it can potentially save you from being embarrassed during the Q&A session after one of your talks.

SEMINARS

I encourage CaMOLab members to attend relevant seminars across campus such as the ACMS colloquia, AME department seminar, and MASS seminar. Seminars are great opportunities to learn from experts in your field, learn about other fields you may be interested in exploring, and gain intuition for what constitutes a good, effective talk. In the spring semester, Notre Dame faculty candidates give their job talk in these seminars. If you are interested in a career in academia, I encourage you to attend these to get a sense of what constitutes an effective/ineffective faculty job talk. I also expect CaMOLab members to give talks in these seminars to advertise your work and prepare for conferences and interviews.

CaMOLab resources

There are a number of resources I provide to CaMOLab members that will be helpful, and often necessary. All of my open-source codes can be found on GitHub (https://github.com/mjzahr) and my private ones are on Bitbucket. I also provide a number of templates for papers, posters, and slides in a private Bitbucket repository. I also include a number of necessary documents (also available on my website): (1) Author Contribution Statement, (2) performance reviews, (3) my advice, expectations, and policies (this document), and (4) advisor-advisee expectations. I also use private Bitbucket repositories to manage all of my papers and proposals. I will give you access to the private Bitbucket repositories once you join the CaMOLab.

References

[1] Marcia K McNutt, Monica Bradford, Jeffrey M Drazen, Brooks Hanson, Bob Howard, Kathleen Hall Jamieson, Véronique Kiermer, Emilie Marcus, Barbara Kline Pope, Randy Schekman, et al. Transparency in authors' contributions and responsibilities to promote integrity in scientific publication. *Proceedings of the National Academy of Sciences*, 115(11):2557–2560, 2018.