Pittsburgh Interdisciplinary Mathematics Review
Volume 1, Number 1, April 2024, Pages 105–123
https://doi.org/10.5195/pimr.2024.28

CALC 1

Careers, Advice, Luminaries, and Community

Section Editor: Neil MacLachlan

Department of Mathematics, University of Pittsburgh, Pittsburgh, PA
E-mail: pimr.calc@gmail.com

About This Section

CALC is the section of PIMR which focuses on career preparation, advice, and facilitating the development of a diverse and inclusive mathematics community by highlighting the work of a wide variety of luminaries, especially those not typically represented, in the mathematical sciences. Each edition will feature short articles condensing information regarding careers in mathematics. In addition, there will be a short profile of a mathematical professional describing their path to mathematics and individual experience. There will be quite a bit of resource aggregation which will hopefully allow interested parties to more easily learn about careers in interdisciplinary mathematics, and the larger mathematical community (many links are embedded so if you are reading a paper copy you can visit "pimr.pitt.edu." to access these). Most importantly this section is dedicated to you the reader, and the mathematics community as a whole, so if you have any questions you would like us to look into, or if you would like to share your own perspective don't hesitate to email.

Careers in Mathematics

As most people are aware, mathematical knowledge is becoming all the more valuable in the 21st century. There are a wealth of career options for those interested in mathematics. Some see mathematics as highly specialized and of limited applicability to the "real world". However, the reality is that a strong technical background is a massive advantage in the current career landscape. Even if you don't go on to use your theoretical math skills in your day to day life the modalities of thinking you develop are an asset. While the academic job market is tight mathematical jobs in general are becoming all the more plentiful. The US Bureau of Labor Statistics projected a 29% increase in math occupations between 2022 and 2032 with statisticians and data scientists having the highest predictions within the cluster at 32% and 35% respectively [2]. Beyond these in

vogue positions people with mathematical backgrounds succeed in myriad fields, if you are interested in seeing the wide variety of careers and people who occupy them check out the Society for Industrial and Applied Mathematics, SIAM, career brochure [21], or the American Mathematical Association's 101 Career's in Mathematics Book [8].

All this being said, not every math major is equally equipped for industry roles. If you would like to enter directly into industry after your bachelors it is wise to consider other mathematically related majors such as engineering, applied math, actuarial math, statistics or computer science. Above all what really matters is experience; if you do a pure math major, but develop software you share on your Github, or take part in industry internships, you can be highly valued. It is unwise to expect a job based on just having a math degree, you need to tailor your math degree to the job you would like to have. Many people who obtained a bachelors in mathematics and went directly into industry recommend taking as much computer science and statistics as possible [8]. That being said a pure math major is an excellent choice if you plan to continue on to graduate school.

Advances in computational capabilities and data availability have not only increased the importance of mathematical professionals in industry, they have also changed, and will likely continue to change how mathematical research is done in academia. It is an exciting time to be a math person, what it means to do math is in flux so there are all the more opportunities to engage in new ways.

Preparing for Graduate School

Most jobs in mathematics require a college degree. Not every mathematical professional attends graduate school, but many do. As any undergraduate math major quickly learns four years is hardly enough time to learn much mathematics. Driven by curiosity they choose to pursue graduate school. If this sounds like you the first thing to consider is what sort of degree you actually need.

Master's degrees tend to be two years, in the states, and are typically more focused on training for industry work, or remedial preparation before a PhD program. Most Master's programs are not funded, they serve as a cash cow for universities. This means they can potentially be exploitative and despite the allure of a quicker entry into the workforce can be detrimental. Master's degrees could make sense for you if you plan to get specialized training to pursue a specific, high paying, job in industry. Master's programs in education could also make sense if you would like to teach in an elementary or high school setting. There are many different routes to teaching math which largely depend on state laws. If you would like to pursue a PhD, but have minimal research experience, a low college GPA, and/or limited advanced coursework, some people may suggest getting a Master's in order to be accepted to a PhD program. This is definitely a possible route, but as described above has some limitations. Working as a research

assistant or in industry, while taking a few advanced courses if possible, may be a more effective and less costly path. Post-Baccalaureate/Bridge programs are another possible path and many provide funding.

While all of these routes can allow one to work in a mathematical capacity, the usual trajectory involves a PhD. These programs can range from four to six years, with much depending on how long thesis work takes. The typical candidate graduates at the end of their fifth year. They are challenging, and time consuming, but allow you to become a true expert in some mathematical topic through your research. There is so much math to be learned and appreciated, a PhD gives you the opportunity and financial support to do so. It also allows you pursue a career as a professor, or work at the highest level in industry. Many mathematics PhD programs are strongly geared towards preparation for academia, so if you do choose to go this route, but have an interest in industry, you will need to find a way to gain the necessary skills. Industry or national lab careers are becoming all the more common for graduates, even in pure disciplines, due to the saturated academic job market. Math PhD's can get hired in industry roles without relevant experience since some employers understand the capabilities thesis research in mathematics requires and trust their ability to learn topical skills.

Above all I would urge anyone who is considering graduate school directly after graduation without detailed thought about what you want your life to look like in the future to take a beat. You have time, and graduate school is a big commitment, you'll thank yourself later if you research things properly and come in deeply committed and certain. That being said it is more typical to apply to PhD programs in your final year of undergrad, and it is much easier to do so when you are immersed in an environment with the relevant resources. Through my own application process I have learned that some schools are hesitant to accept student who have been out of school for long periods of time since their skills may not be as fresh.

Preliminaries

What Should I do Right Now?

There is no catch all answer to this question. Your own experience with mathematics at the point you decide to pursue graduate school is unique to you. However, it is very cool to be early to the mathematical party, unlike conventional ones. As students come to understand, math education is very linear until one has completed the calculus sequence. After a few core courses such as linear algebra, real analysis, abstract algebra, and ordinary differential equations, a math major can pursue a wide variety of topics. It is highly beneficial to your overall understanding of mathematics for you to finish calculus early, and ideally your core undergraduate courses as well. You will be able to take far more graduate level courses, and be a much more competitive applicant. Thus if you are considering applying to graduate school and are in high school or your first or second year

of college you're in an incredibly good position. You have a lot of time to set yourself up for success. Many applicants don't decide to take the PhD route until later in their education and this means they have to scramble to have a strong research, academic, and extracurricular background. That being said it's never too late. It's nice to be ahead of schedule, but life isn't always so simple. Some people get a PhD much later in life, if you want to, you can absolutely do it.

If you are planning to apply to graduate school you should meet with your academic advisor, research mentor, and/or your undergraduate director to discuss next steps based on your individual interests and background. Below I will describe components of a PhD application and how you can work towards have a strength in each area.

Note that there are numerous opportunities, and it can sometimes be unclear what is more worth your time. A useful piece of advice I have received is the importance of standing out and being recognized at a number of different levels. For instance winning an award in your home school's math department, or receiving strong letters of recommendation, or advanced coursework would be one level, but being acknowledged at the university level, through research funding, honors programs, or the deans list is another level. It is particularly valuable if you can distinguish yourself outside your home university on the national or international level.

Along similar lines, while you can feel obligated to take on numerous opportunities, it is important to pace yourself. Burnout is all too common in academia and ultimately as a graduate student you will need to self structure and find your own work life balance. Make sure to incorporate self care into your day to day life, and put yourself in a position to be successful by being proactive if any problems arise.

Coursework

Many math majors have flexible coursework requirements, especially here at Pitt. One person's math degree can be very different from another's. This is important to understand if you would like to attend graduate school, since advanced coursework, especially graduate classes, can make a big difference to your application. Most math departments have an honors track which will prepare you for graduate school, as well as potentially giving you the option to do a senior thesis. While desired coursework requirements vary generally speaking a prospective graduate student is expected to have taken courses in calculus, real analysis, and linear algebra at the bare minimum. The other coursework depends greatly on area of research interest, and whether you are pursuing a pure or applied track. Abstract algebra and topology is expected for a more pure student, while ordinary differential equations, partial differential equations, and numerical analysis is expected for an applied student.

Opportunities for Undergraduates

There are many competitive and rigorous math programs for undergraduates. Some of the most well known include the Budapest Semesters in Mathematics [12], Math in Moscow [14], and the National Science Foundation's Research Experience for Undergraduates (REU) programs. The math department here at Pitt also offers summer research funding through the Painter Fellowships, and there are various similar opportunities through other parts of the university. Some opportunities, such as REUs, are largely limited to US citizens. However, this is not always the case for more information consult [4, 5]. If you're interested in math competitions you can also take the Putnam Exam. The department offers a seminar course each Fall to prepare students, however you can sign up and take it without such preparation.

Some of these opportunities are research focused while others consist of advanced coursework or synthesize the two. All of them will help you stand out as a PhD applicant. Below you can read testimonials from Pitt students who participated in some of these opportunities. For more information regarding undergraduate research opportunities consult the feature article of CALC 1 by Pitt's Undergraduate Director Prof. Jason DeBlois. If you do conduct research you can (and should) seek out opportunities to present your work at conferences.

Budapest Semesters in Mathematics [Evan Hyzer]
If you are interested in mathematics and want to travel abroad, go to Budapest Semesters in Mathematics! You can spend a semester with people who have similar interests, with the opportunity to make lasting friendships while learning lots of math and experiencing a different culture. The program is at an advanced undergraduate level, and specializes in combinatorics and graph theory, but it includes courses in group theory, measure theory, and machine learning. There are many research groups as well. The lodging is a spacious apartment in Pest, which is the city center, or in a suburb of the city. Outside of the program, the city of Budapest is beautiful, rife with great architecture, museums, bathhouses, bars and bookstores. Additionally, there are many opportunities to travel around Hungary and eastern Europe. It was great for improving my mathematical maturity as I got to see more advanced topics and do research, but I also had lots of fun!

Chancellor's Undergraduate Research Fellowship [Lark Song]
I was awarded the Chancellor's Undergraduate Research Fellowship in Spring 2024 for my thesis on the truncated octahedral conjecture, supervised by Dr. Hales. The Frederick Honors College at Pittsburgh actively supports undergraduate research through various funding initiatives, including the Chancellor's and Brackenridge Fellowships—I encourage you to apply for all of them! A standout feature of this fellowship is the requirement to write three blog posts for the Honors College website, each highlighting a different phase of my project. These writings offered moments to reflect on my journey into research, the

guidance I received from my mentor, my growing fascination with the research problem, its broader impact, and sharing the excitement and insights of my discoveries with those outside the math community. This reflective practice, along with the recognition from the university, enriched my educational experience, reinforcing my decision to pursue a doctoral degree after graduation.

Painter Fellowship [Adam Hicks]
I participated in the Painter Fellowship during the summer of my Sophomore year, under the advisement of Dr. Thomas Gilton. After building a firm foundation in set theory, we studied the paper, "Infinite Combinatorics revisited in the Absence of Axiom of Choice" (Csernak and Soukup, 2022), which derives analogues to classical combinatorial theorems in a revised axiom system, excluding Axiom of Choice. The work was challenging and highly rewarding. I was able to examine theoretical math in an entirely different light than any other class I had taken. Each week, I would closely read a portion of text, study a particular proof or two, and then meet with Dr. Gilton and explain what I learned. Working one-on-one with Dr. Gilton pushed me to my intellectual limits, and it allowed me to explore a topic that I had little prior knowledge of but a high level of interest in. I would recommend the Painter Fellowship to anyone who has a mathematical niche they wish to explore and is excited to push themselves farther than they have before.

Painter Fellowship [Annie Wang]
The Painter Undergraduate Research Fellowship is a wonderful opportunity offered by the Math Department for undergraduates to get some research experience. A student is paired with a faculty mentor within their area of interest. The Painter Fellow and his or her mentor choose the type of research and the research project, for example, doing original work or reading an article. I was a Painter Fellow in summer 2023 under the supervision of Dr. Catalin Trenchea. We worked in fluid dynamics, using the transport and Navier-Stokes equations to model bioconvection, which is the convective motion of micro-organisms suspended in fluid. I read some research papers on mathematical and numerical models of bioconvection and tried to rederive and regenerate the results. I learned deeper theory in numerical analysis than in the courses MATH 1070 (Numerical Mathematical Analysis) and MATH 1080 (Numerical Mathematics: Linear Algebra) such as Cauchy's one-legged q-method. I also got a taste of what research in this area looked like. The Painter Fellowship allowed me to explore topics that interest me beyond what is taught in the classroom and sharpened my analytical and creativity skills.

TECBio REU [Neil MacLachlan]
The Training and Experimentation in Computational Biology REU at Pitt is an excellent opportunity for students interested in Mathematical Biology. Prof. Jon Rubin and Prof. Bard Ermentrout rotate as a mentor from the math department. The REU provides a

venue to engage in an interdisciplinary community since many of the other students come from non-mathematical background. I found this particularly enriching. The environment was very supportive, the program provided university housing, a VR headset, and a $ 6,000 stipend. Note that this is an especially good opportunity for Pitt students since they have different pools of funding for local students which means you are more likely to be accepted.

Application Process

Choosing Schools

The process of choosing which graduate programs to apply to is just as difficult as it is important. You will be spending quite a few years in your program, so you need to select a location which will allow you to thrive socially, emotionally, and economically, as well as academically. Almost every math PhD program is fully funded, this means if accepted you will be paid by the university to work as a graduate student. Usually this funding is provided through a combination of teaching assitanceships (TA), research assistanceships (RA), and internal or external fellowships. From my experience typical stipends range from $ 20,000- $50,000. Much of this depends on local cost of living and whether the graduate student body is unionized. Usually students teach in the first couple years of their PhD then, if funding is available, their research advisors provide support in the form of a RA.

Another important decision is how many programs you should apply to. Each program typically has an application fee of $50-120, while fee waivers are sometimes available this does mean financial reasons may be a obstacle. However, your graduate school has a large impact on your career, it is worth dedicating money to. I have heard widely varied pieces of advice, some people encouraged me to apply to just 2-5 programs, while others suggested at least 10. Ultimately I applied to 16, which I thought was a lot, but I have since met people who applied to 20 or more. This can be a lot of work for you, and tedious for your letter writers. To mitigate this issue make sure to send them information regarding your selections as early as possible and all at the same time.

There are a wide variety of math programs available, knowing what strata of schools to apply to, based on your background, is important for saving both money and time. While you can look over the AMS program tiers, US news, or QS World University Rankings, this only really gives one a vague idea of how programs are perceived and not necessarily how good they are. Furthermore, these are aggregate rankings based on the general quality of the department at each institution, not the quality of research in your particular area of interest. Thus it can be very helpful to talk directly to your faculty mentors about what schools you should consider applying to based on your interests and experiences. Note that you should focus on individual people who you see as prospective

graduate advisors, not look at schools as a whole. It is a good rule of thumb to only apply to programs which have at least two faculty you would be interested in working with. Professors can and do leave universities so it is best to have numerous options. If professor W is your dream advisor on paper, but you don't get along in real life, then you still have the option of professor X, and ideally professors Y, and Z.

Fellowships

There are numerous fellowships available to aspiring academics, especially those who are U.S. citizens. I will only discuss the most fundamental here, the National Science Foundation (NSF) Graduate Research Fellowship Program (GRFP), but links to other fellowships are included below. If you're applying for graduate school in any scientific field and you aren't applying for the GRFP then you're making a mistake. A GRFP fellow will received three years of financial support, which includes at $37,000 stipend as well as $16,000 which is paid directly to the university [6]. Not only does the GRFP show you are valued as a researcher at the highest level, it provides you with a more comfortable life throughout graduate school. Furthermore universities see you as a financial asset, rather than a burden, as in the case for most graduate students who pay no tuition. For context a typical graduate stipend associated with a teaching or research assistanceship can range from $18,000-$50,000. Usually if you receive an external fellowship the program will supplement it if it is below the usual stipend. As a GRFP recipient you would not be required to TA. Notably you are allowed to apply for the GRFP once as a graduate student and once as an undergraduate. So even if you aren't an exceptionally strong candidate as a undergrad you don't loose anything by applying. Furthermore, you only compete against others in your pool so it is less competitive at the undergraduate level. Lastly, there are quite a few fellowships offered proportional to the number of applicants. In the 2023 cycle approximately 20% of applicants received the fellowship. The GRFP application differs from a PhD application in the fact that it requires a short research proposal regarding a project you plan to complete in graduate school. This is non-binding so receiving the fellowship does not mean you must do the research you proposed. This is an opportunity to show your capability as a scientist by constructing a convincing and well thought out research plan. The norm here is to adapt and extend research projects you have already worked on. Even if you would ultimately like to pursue a different subject in grad school it is prudent to propose extensions of your current research since you can rely on your faculty mentor for help with your proposal. People do propose novel projects in areas they have little experience with, but it is much more difficult to create a good proposal. If you are a Pitt student and are interested in learning more about the GRFP and other fellowships I strongly recommend reaching out to the Office of National Scholarships and Post-Graduate Success [3].

Personal Statements/Statements of Purpose

Writing a good personal statement is an art prospective graduate students become all too acquainted with. From colleges, to scholarships, REUs to fellowships, your skill as writer will have an impact on your career. While these statements can seem tedious at times, if you do plan on going into academia writing skills are essential. It is critical to know your audience and what they look for in an applicant. I urge you to take advantage of the resources at your university. Here at Pitt the Office of National Scholarships and Post-Graduation Success which is embedded in the Frederick Honors College provides information and assistance with applications for a wide variety of scholarships and fellowships. They have a team of scholar mentors who can help with your statements for fellowships. Through honing these for their earlier application deadlines you will develop material for your graduate school statements. It is not expected that you will write an entirely new statement for each school, however you should customize it to include relevant details of who you would be interested in working with and why the school is a good fit. Finishing these statements as early as possible is very helpful since you should send them to your letter writers to help them construct better recommendations.

Diversity Statements

Many universities have recognized the problem of diversity in academia. It is a particular focus in STEM fields. As part of your PhD application you may be asked to submit a diversity statement of some sort where you describe how your goals and personal perspective will contribute to and support the diverse, equitable, and inclusive environment the university is working towards. Its important to think about this early on. Each and every person has a unique perspective so this can be a good place to speak to your individual differences. Furthermore, as a teaching assistant and potentially as a professor in the future, you will influence how other people within academia relate to math. It is critical to have DEI in mind if you would like to support all of your students and peers.

Letters of Recommendation

For graduate school applications letters of recommendation are often very highly weighted. Each reviewer is different, but in general they make a huge difference. It is important to secure strong letters of recommendation, ideally from tenured faculty. Generally graduate schools and fellowships require three letters of recommendations, some may allow four so having more strong letter writers is always a good thing. A good letter writer needs to have a lot of exposure to you in a classroom and/or research setting. Even if you took a class from a very famous professor and got a good grade a letter from them may not be as strong as one from a less renowned professor who can speak to your capabilities as a researcher. The process of getting strong letters of recommendation is yet another reason why those who start planning for graduate school early are at an advantage. If

you take part in undergraduate research, or take advanced courses, your letters can be exceptionally strong. A core, often disregarding, part of getting a strong letter is actually working with your letter writers on the letter's contents. If you choose skim over a research experience, or academic difficulty in your personal statement it may be wise to ask your letter writer to address it for you. This not only lifts the onus from your writing, but provides evidence for the claims you make.

General GRE and Subject Tests

The General Graduate Record Examination, GRE, and math subject tests have long been a part of applying to graduate school. However, they are in the process of being phased out. Students could not safely take the GRE during COVID, which resulted in universities removing the requirement and many have chosen to not reinstate it. The general GRE test is of almost no importance for applying to a graduate program in mathematics. All of the math on the exam is elementary, and the other components are not weighted highly. The math subject test does cover upper level mathematics: real analysis, calculus, abstract algebra, linear algebra, and probability. These topics are of interest to graduate programs, so the math subject test is considered by reviewers. Since many programs no longer require this test, or refuse to accept it, you may choose to not take it. A nice feature of the test is that it is universal, allowing students with less advanced coursework or those from smaller colleges to show their mathematical aptitude. I personally chose not to take it and have still received strong acceptances. It did however slightly limit the schools I could apply to. Note that you do not necessarily have to do this. I later learned that many people reach out directly to programs with GRE requirements and are encouraged to apply anyway without GRE score.

Description of Exams [Eli Ullman-Kissel]
These exams are now taken at testing centers on computers, and they are offered three times a year in September, October, and April. Finding a testing location and sending scores to graduate programs is pretty much identical to the SAT or ACT. The topics on the math subject test are quite thorough. For example, on my exam, I had to find the null space of $XA - AX$ given A, verify that a distance function defined a metric, and find the probability of a coin landing entirely in a square. These were just three problems out of the sixty-six problems on the 2 hour and 50 minute exam. It would be very useful to have Advanced Calculus (MATH 1530/1540) and Abstract Algebra (MATH 1250) completed prior to taking the exam. I did not have either of these courses completed when I took the exam, and I certainly struggled because of that. If you can not take these classes before the exam, you should plan to begin studying for the exam at least a month prior to taking it

Opportunities for Marginalized Groups

Diversity in mathematics and the sciences is a problem of note and many programs have the explicit objective of supporting marginalized groups in academic careers. This takes the form of dedicated fellowships as well as bridge programs designed to close educational gaps induced by systemic bias and limited opportunities. The GRFP does take this in consideration as well, but there are some programs exclusively for marginalized groups such as the Ford Foundation Fellowship, the EDGE for women program, and various mentorship opportunities, such as those offered through AWM [1, 19, 24]. There are also conferences such as the NAM Undergraduate MATHFest [11].

Post-Bac and Bridge Programs

Especially if you decided to pursue the PhD track later in your undergraduate degree you may have difficulty getting into competitive PhD programs. Some students choose to pursue a Master's degree to strengthen their application, however as previously described this can be expensive. Another route is a Post-Baccalaureate program. These programs are specifically designed to strengthen the background of undergraduates who didn't have the chance to conduct research or take advanced coursework. Some even have career or research mentorship programs or host workshops regarding graduate school applications. Numerous opportunities exist which are fully funded and dedicated to supporting students from historically underrepresented groups in math such as Northwestern's Causeway, and the University of Michigan's Marjorie Lee Browne Program [23, 13]. Pitt even has our own Post-Bac program [18]. Many of these programs have application deadlines in the Spring so they can be a good thing to look into if you haven't received PhD offers you'd like to pursue.

Interviews, Acceptances, and Rejections

January-March is an exciting and trying time for PhD applicants. You will likely receive rejections and have to cope with the feelings associated with them. Math PhD are competitive, but there are opportunities out there. Many students at Pitt go on to PhD programs, so you have a good chance of getting accepted. Math PhD programs tend to be a bit slower than other departments at sending out offers. You may not hear from them until February or even March. Some departments do conduct Zoom interviews, or even fly candidates out for in person interviews, but most accept students without any contact. If you do get an interview it is important to be prepared and knowledgeable regarding the program and the professors you would like to work with. Usually the interviews are not technical, but I have heard of one program which asks students to solve undergraduate level problems. This is highly unusual. From my own experience interviews tend to be informal. They are primarily trying to gauge your interest in research which is strongly associated with your ability to complete a PhD. You may be asked about other programs

you have been accepted to. This is a difficult question to answer and can be surprising. Some schools practice strategic rejection policies and don't accept strong candidates if they believe they will not actually attend. You have no obligation to answer these types of questions.

Deciding which Program to Attend

This is of course a very important decision. After you are accepted you are typically invited to an admitted students weekend. The department will pay for your travel, and lodging. This is an excellent opportunity to experience the location and community. You also will get to meet with faculty who have similar research interests. Even if you decide to attend another university the chance to make relationships with faculty and other prospective students is invaluable. I have heard that if you make a good connection it is common to reach out to professor at other universities and do research with them over the summer. I was urged to visit every university I would consider attending despite how busy it would make my spring semester. If it is possible I would strongly recommend taking a reduced load of courses and research in your final semester, from my experience the process of visiting schools is incredibly time consuming and disrupts typical academic routine.

I have found that talking with current PhD students or alumni is especially enlightening. There is quite a bit of information regarding programs which just isn't available on the internet. This is a good time to ask difficult questions. What is the attrition rate in your program? Is the stipend sufficient for the local cost of living? Is the graduate student body unionized? Do graduates get jobs similar to the ones you hope to get? Will your prospective advisor be taking students? Much of your PhD experience will depend on the culture of your department and your advisor. Think this over thoroughly and speak with your mentors. Beyond the academic aspects you should evaluate whether the location is suitable for you. You will be there for the next 5-6 years of your life, so if you dislike the weather or it isn't a good fit socially that should be incorporated into your decision. Remember to decline offers as soon as you can, the system is imperfect and many people on wait-lists benefit greatly if you can rule out options before the deadline. People tend not to do this which can result in very stressful situations on April 15th. I would recommend making the decision as soon as you can and then never looking back.

Timeline

Understanding the timeline for your graduate school applications is critical to your success. Ideally it begins in your Junior year. From my understanding this is typically the process.

- Fall of Junior Year
  - Try to identify your areas of research interest

  - Conduct research
  - Take advanced classes
  - Identify letter writers among research mentors and lecturers from advanced courses
- Spring of Junior Year
  - Take the GRE subject test if necessary
  - Understand fellowship and scholarship opportunities and their associated timelines
  - Ask for letters of recommendation
  - Begin to look at programs and make decisions as soon as possible
  - Discuss programs with letter writers and get their opinions
- Summer Before Senior Year
  - Conduct research
  - Make final decision on programs
  - Work on applications for fellowships
  - Work on applications for Programs
- Fall of Senior Year
  - Take the GRE subject test if necessary
  - Submit fellowship applications (usually September-November)
  - Submit graduate school applications (usually December-January)
  - Contact professors at institutions you are applying to
- Spring of Senior Year
  - Timelines to hear back vary a lot (early January-March)
  - Attend interviews
  - Attend admitted student open houses
  - Universal date to accept offers is April 15

Walter Richard Talbot

Education and Pitt

Walter Richard Talbot (1909-1977), a University of Pittsburgh Alum and the fourth African American to ever receive a PhD in mathematics, is an inspirational figure. Talbot paved the way for future African American mathematicians through his pedagogy, advocacy, and community work. He began his studies at the University of Pittsburgh in 1927. Talbot initially pursued a major in physics, but the required laboratory hours clashed with his job as a waiter, which he needed to keep in a large part due to the Great Depression [15].

This led him to pursuing a non-laboratory major, mathematics. Luckily he found many supportive and kind professors in the math department, including Montgomery Morton Culver, and Forest Almos Foraker. Culver served as Talbot's advisor for all seven years he spent at Pitt, supervising his undergraduate studies, as well as his Master's and PhD theses [15].

Note that Culver is the namesake of the Pitt Math Department's annual undergraduate academic award. Talbot received a Bachelors of Arts in Mathematics with honors in 1931 [17]. When Talbot was awarded his PhD in Mathematics in 1934 he was only preceded by Elbert Frank Cox, Dudley Weldon Woodard, and William Schieffelin Claytor [15]. Talbot was an algebraic geometer, his Masters and PhD theses are titled *A Study of a Certain Set of Transformations in the Argand Plane*, and *Fundamental Regions in S-6 for the Simple Quaternary G-60, Type I*, both of which are available at the University of Pittsburgh Library. One of the current faculty members in the Math Department at Pitt, Professor Thomas Hales, has written an expository piece describing Talbot's Thesis [7]. From my own archival research on mathematics at Pitt in the 19th and early 20th century, the Math Department was highly applied, and largely a subsidiary of the School of Engineering until the early 20th century. Professor Hales believes that Talbot's mentors were likely the first algebraic geometers at the University [7]. Through Culver, Talbot himself is an academic descendent of Felix Klein, the namesake of the Klein Bottle and Klein four-group [7, 20]. Foraker taught Talbot geometry and encouraged him to go through the process of election to the prestigious scientific research honors society, Sigma Xi [15].

Lincoln University

Directly after receiving his PhD Talbot was hired as an assistant professor at Lincoln University in Jefferson City, Missouri [16]. Lincoln University is a historically black college and university (HBCU). It originated as Lincoln Institute in 1866 and was established as an accredited four-year college of arts and sciences the year Talbot arrived, 1934. Talbot

stayed at Lincoln until 1963. Despite his achievements and academic pedigree Talbot published little research following his PhD [16], due to the limitations of attending a smaller-scale (and historically underfunded) institution, an issue that affected many Black mathematicians at HBCUs. Talbot himself writes: "As for research, very little comes from any of the small colleges and the TBIs (HBCUs) are no exception." [15] While these constraints hindered his ability to publish, he used his position as an educator and leader to be impactful in a different way. He rose through the academic ranks at Lincoln from associate to full professor, to Dean of Men, and by 1944, he was promoted to the Head of the Mathematics department [9]. Talbot managed three significant promotions in less than a decade, and quickly became a beloved faculty member. His home was even known as "The Monastery," because it was a hub of intellectual conversation frequented by Lincoln University scholars [16]. Talbot and his wife Kathleen were pillars in the community and were known for regularly housing important visitors, such as Nathaniel Sweets, an equal rights activist whose publications at the St. Louis newspaper *The American* advocated for fair housing and educational improvements for Black citizens [16]. Talbot would serve as Department Head at Lincoln until 1963, when he took an offer for the same position at Morgan State University [15]. However, his impact on Lincoln University as its youngest Doctor of Philosophy and as a cherished leader in Mathematics education would remain [16].

Morgan State University

Morgan State University (MSU), previously known as the Centenary Biblical Institute, was a recipient of a grant from Andrew Carnegie in 1917 and purchased by the state of Maryland in 1939 in an effort to widen opportunities for Black Americans [16]. Indeed, the quality of education and the accessibility of opportunities for Black students would improve in the time that Talbot served at Morgan State, a change which he most certainly contributed to. In only the 12 years that Talbot worked as Department Chair at Morgan State University, he would not only co-found the National Association of Mathematics (NAM), he would also become a member of the Maryland Academy of Sciences, direct a summer institute in mathematics, and introduce the use of computer technology to his students [16]. In 1975, two years before Talbot retired, Morgan State earned the ability to award its students doctoral degrees [16]. In 1978, a year after his passing, Morgan State created a scholarship in his name [16]. During and after his time at MSU, Talbot both witnessed and actively participated in breakthroughs in the education of Black Americans.

NAM and Legacy

Talbot's role as a national actor in mathematics began in earnest in 1969 when he served as the director of a conference for mathematics curriculum at HBCUs, and co-founded

the National Association for Mathematicians (NAM) at that year's Joint Mathematics Meeting [15, 16]. In many ways this year was pivotal in increasing the participation of Black mathematicians in the larger math community [16]. All of these advances occurred just eight years before Talbot would retire. Despite his limited opportunity to make an impact on a national level throughout the majority of his career, when he was given the chance he rose to the challenge. Since its inception, NAM has been focused on supporting underrepresented groups in math [10]. This is accomplished through community-building, conferences, and other forms of professional development efforts. One of their most prestigious events, the Cox-Talbot lecture series, given every year at JMM, was created in his honor. Mathematician Johnny L. Houston wrote that "more than any other single individual, it was Talbot's leadership, guidance, organizational skills, and networking skills that raised funds for the establishment of NAM." [9]

Walter Richard Talbot was not only the fourth African American to get a PhD, Lincoln University's youngest Doctor of Philosophy, one of the seventeen co-founders to establish NAM, and a member of the American Mathematical Society and the Mathematical Association of America, he was a mathematician whose dedication was to both furthering his field as well as furthering opportunities for those within it.

Community

Anyone can be a math person. Even if you may have struggled in a math course, or you don't fit the typical socially constructed image of what a math person looks like, there is space for you in mathematics. You don't need to go to graduate school or become a professor to be a math person, math is for everyone, and in the words of Francis Su "Mathematics is for Human Flourishing" [22]. So pick up a book, talk to a friend, watch a video, or just think about the patterns that surround you. Mathematics is everywhere and it is just as much yours as it is anyone else's. Below are links to a number of resources which show the incredible diversity in math, existing organizations, and how people are working to create a more diverse, equitable, and inclusive mathematical world. In addition, I have aggregated additional professional resources which I hope will be beneficial in navigating your mathematical career.

Link Aggregation

Math Community Organizations

- Association for Women in Mathematics
- Sines of disability
- Spectra
- Mathematicians of the African Diaspora
- Center for Minorities in the Mathematical Sciences
- National Association of Mathematicians

Opportunities for Undergraduates

- JMM Pi Mu Epsilon Presentations
- Young Mathematicians Conference
- MAA MathFest
- REU Finder
- Math REU Programs
- American Mathematical Society REU Programs

Graduate School Information

- AMS Program Tiers
- Data-Based Assessment of Research-Doctorate Programs
- University of California Irvine Advice

Funding Opportunities

- NSF Graduate Research Fellowship Program
- Hertz Fellowship
- DOE Computational Science Graduate Fellowship
- Churchill Scholarship
- Fulbright Program
- Marshall Scholarship
- Math Alliance Bridge Programs List
- GEM Fellowship
- NDSEG Fellowship
- Soros Fellowship for New Americans
- Pitt Office of National Scholarships

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