GET A MATHS JOB

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INTRODUCTION

We start with a seemingly unrelated question:

> *Are there more words in the English language that begin with the letter "r" or that have the letter "r" in the third position?*

Most people say that there are more words that begin with the letter "r" but they are incorrect. It is easier to think up such words rather than those that have "r" in the third position and this leads them to draw a wrong conclusion. This is called the *availability bias*: our mind gives more weight to the available information.

Here is another question for you to consider: are there more mathematicians in academia than in industry? Most of your available information comes from academic mathematicians because you have spent so long in their classrooms observing their existence. However, after the lesson on the letter "r", you are not so willing to let availability cloud your judgement. Indeed, there are many more mathematicians in non-academic jobs; they are just not as available to you and they don't usually sport *mathematician* as their job title. In short, the majority of demonstrable career advice comes from the minority.

The point of this paper is to punch your availability bias square in the teeth and give you a *non-academic* career guide to becoming a working mathematician.

It should not need to be said, but a career in maths looks different depending on who you are. This might be the wrong guide for you if your ideal job is at a university. But it's still good to know that you can flex your mathematical noggin outside of academia in rather neat ways, from using machine learning to optimise the performance of an app, to analysing statistics that better target medical resourcing. What really matters is that whoever you are, you should try to find a job where you do the kind of maths that makes you happy.

Summary

Most mathematicians end up outside of academia and are not readily available for career advice. This means that most advice is delivered by academics who are – by definition – not well-placed to advise on how to get a job in industry.

Mathematicians do exciting maths in industry but sadly don't often take the opportunity to come back to universities to tell you all about it.

NOT ALL MATHEMATICIANS ARE CREATED EQUAL

When I finished my PhD in number theory, I took a job as an options trader and met many sharp minds working on a vast array of interesting problems. Many of these people were definitely *sharp* enough to become academics; they had instead chosen to work on problems relating to financial markets and obviously liked the fast-paced environment that came with trading. Of course, the mathematicians I met at various universities during my PhD were certainly sharp enough to trade options; they were clearly more suited to solving deeper problems, developing theories, etc.

Mathematicians are not all the same. We all like working on different problems in different environments. I was a strong options trader because I'm an intuitive mathematician who is able to work with other people; I like thinking quickly and getting *good-enough* answers that allow me to respond with speed to novel changes in the market. Some people are not great options traders because they like everything to line up perfectly before they pull the trigger; inevitably they are often late to the party. But maybe they would make brilliant algebraic geometers or bioinformaticians. The point is that we are not all cut from the same cloth.

> "Do not let people tell you what is interesting – you must find it out for yourself."

Interesting mathematics is *subjective*. The differences between mathematicians should be celebrated. There's a role for everybody — it can just take some time to work out what it is! What often happens is that people continue along a well-trodden path, meaning that they will complete an undergraduate degree specialising in maths, then honours in maths and then maybe a PhD. It can be easy to get caught on the treadmill here, but I would encourage everybody undergoing this process to continuously try and work out what kind of mathematics they like. If you surround yourself with the right problems and the right environment *for you*, then you will flourish. A mismatch, however, could bog you down for years. Do not let people *tell* you what is interesting – you must find it out for yourself.

On this note, people will also try to push you in the direction of *important* maths. When I was working on my PhD research (in explicit methods in analytic number theory), a visiting PhD student (algebraic number theory) told me my research was not important. At the time, my response included more swear words than good manners should permit. Let me stress that importance is only marginally less subjective than interest. Even if you should win a Fields Medal, your work still won't be important to everyone.

You could spend your whole life trying to prove the Riemann Hypothesis or you could spend your whole life working on problems that are interesting and of importance to *you*. To summarise, don't let the scent of *importance* draw you away from the maths that gives you meaning.

Now have a think. What sort of mathematician are you? This is not an easy question to answer. The best place to start is with this question: do you love what you are doing day-to-day? If the answer is yes, then you can probably just keep going. If the answer is no, then maybe there is a style of mathematics that suits you better.

On this note, there is no need to staunchly adopt a classification. When I was a student, there were plenty of heated debates on pure maths versus applied maths, analysis versus algebra, industry versus academia and so on. I myself proudly wore the *pure maths* badge for some time. But then I got a job as an options trader and I had to back-pedal on the numerous soap box pontifications I had made about how pure maths is the only way. In short, aggressively taking a side will only limit your mathematical opportunities and make you look a bit sheepish when you decide to switch things up a bit.

Instead, think about the pieces of mathematics you have learned that really stand out to you as interesting and important. For reasons I cannot explain, I always preferred calculus over linear algebra. In my later undergraduate years, although I enjoyed subjects in both analysis and algebra, the former was more exciting to me. I really liked Taylor's theorem and approximating functions using polynomials. It just seemed neat that you could do this. In a second year pure maths course, we learnt about prime numbers and I was mesmerised by the difficulty in proving seemingly basic results on such a simply defined sequence of numbers. Given these are my memories from my university days, it is unsurprising that I ended up writing a PhD thesis on explicit methods in prime number theory, where I used calculus and function approximations to study the prime numbers. Surround yourself with the bits of maths you find interesting.

Summary Don't let people tell you what's interesting or important. Try and find this out for yourself. This can take time and you might need to backtrack.

ACADEMIA & INDUSTRY

During the last few months of my PhD, I was having a ~~beer~~ coffee with a professor. I told him that I had accepted a job as an options trader. His face dropped and he remarked in almost-disgust: "why are you going to do a thing like that?"

It rattled me. I couldn't answer the question either; I just knew that I wanted to do something a little bit different for a while (this is actually a rather sensible desire for anybody!). I murmured a cliche and went home for the night with a sodden heart. This happened about six years ago but it's important that we talk about it here.

I did a lot of really fun maths during my PhD and I also did a lot of really fun maths as an options trader. However, I did encounter some people who held the wrong idea that industry (and finance in particular) is the *dark side* where inferior mathematics is done, and your soul is sold off to the highest bidder. The mathematics is not inferior; it's certainly a lot faster as it is swiftly applied. As for the bit about selling your soul, if this is a dramatic way of saying that you won't be the master of your own time, then this is true. Just know that in industry, you will be compensated for the decrease in autonomy, and you can always find a new job if the balance is off.

> "The mathematics is not inferior — it's certainly a lot faster as it is swiftly applied"

It is tempting to copy our mentors and talk about industry being the dark side, but don't be that person. There is no upside to it, especially in a world that now has much more room for mathematicians in industry than in academia. There is no need to limit your opportunity to either of these. Just try and be as open as possible. Things change and you might want or need to as well.

The academic path is cleaner and well-trodden. You will have lecturers, supervisors and a wealth of material online for direction here. As it stands, the competition for post-doctoral and academic positions is quite strong. Tenacity is important; if your chance of a successful job application is p then I suppose you should be comforted by the fact that $1-(1-p)^N$ converges to 1 for large N. That is, keep applying and you will get there (provided of course that p is positive).

> "It's an incredible time to be a mathematician"

In industry, it is an incredible time to be a mathematician. With the explosion in computing power (a punchy line that also happens to be true) and the widespread pickup of artificial intelligence and machine learning, you *can have a job doing maths*. BBy being open to industry positions, you can keep the lights on in your house while you work on applications for academic positions if that's the path you ultimately want to walk. If you've sided with the purists, you may have to choose between shame and no electricity.

Summary

There's plenty of enjoyable maths being done in academia and industry. Learn about the options in both.

You should always look ahead to where you want to get to, and being flexible along the way is going to help you find employment.

THE MAKINGS OF A MATHEMATICIAN

Before we focus on getting jobs, we should talk about the three qualities you need to have success as a mathematician wherever you go:

Clarity: a strong and clear knowledge of the fundamentals.

Conversation: the ability to speak about maths to different people.

Initiative: the drive/resourcefulness to find the problems that you will solve.

I like to call these three qualities the *makings of a mathematician*. Anybody that can mark these off to a high degree is well set for a strong career. Of course, they are sufficiently vague in their current form, so let's discuss them in more detail.

➠ CLARITY

In some sense, this is about smashing it out of the park during your undergraduate years. And I don't mean simply getting good grades (of course, this is important for picking up PhD scholarships and getting to the top of a pile when you apply for your first job). You really need to *grasp* the maths you learn.

Some people say that mathematicians are great at *working in the abstract*. It is ridiculously important that you come back down to planet Earth for visits whenever time permits. Here's what I mean by this: you might be in a first-year calculus lecture where you are presented with the following theorem:

Theorem (Intermediate Value Theorem). *A function $y = f(x)$ that is continuous on a closed interval $[a, b]$ takes on every value between $f(a)$ and $f(b)$.*

Usually, this is followed up with a proof involving those characters ϵ and δ. Of course, the proof is important and don't let anyone tell you otherwise. But the first thing any budding mathematician should be able to do is explain that theorem (or some soft representation of it) to a person in the street. Indeed, a lot of the time just choosing an example or two will be more elucidating:

- If you walk from the lowest point in a town to the highest point, then at some point your shoes will be at the same level as the shoes of the mayor.
- You can't get from the Southern Hemisphere to the Northern Hemisphere without crossing the equator.

Obviously, there is no need to approach somebody on the street with your explanation (the responses range from polite thanks to unsolicited violence). It just needs to be intuitive and in English. And yes, with more complicated theorems, this gets harder and harder to do, but a good mathematician doesn't shy away from a challenge.

The other part of *grasping* maths is to come up with examples. Lots of examples. With the Intermediate Value Theorem, choose a continuous function and check that it works. Find a discontinuous function where it doesn't work. Inhaling theorems and proofs is only useful if you can spit out the examples and applications afterwards.

You should try and do this all the time: Firmly grasp any maths you come across by grounding it with examples and writing down an intuitive explanation in clear English.

I will allow you to be a bit frustrated with me at this point. How on earth are you supposed to do this for every theorem you come across in a maths degree? You can certainly be selective later in the game. By the time I was in my honours year, I knew that I loved analytic number theory, and so I wouldn't spend as much time dissecting the theorems from my algebra courses — instead preferring to focus on the analysis side of things. However, I want to advise you to remain flexible. You shouldn't buy into any strict *algebra vs. analysis* division. Don't fence yourself in.

> "I implore every mathematician to make sure they have a firm grasp of calculus, linear algebra, probability and statistics"

At any rate, I implore *every* mathematician to make sure they have a firm grasp of calculus, linear algebra, probability and statistics. These fields are invaluable for industry in particular. There are many courses popping up these days teaching data science and machine learning at a surface level, so that even non-mathematicians can get their foot in the door. While these have a place, a profound understanding of the basics allows you to dig deeper and understand what the code is concealing to a higher degree. You can tweak and adapt much more readily, as well as explain what's going on to colleagues instead of just admitting that it's a black box to you.

This is a good place to answer the question of how my PhD in number theory helps me to trade options. I get asked this quite a lot. All research relies on the repeated application of fundamental ideas. Of course, I was researching prime numbers, but I was employing Taylor series, testing for convergence, inverting matrices, integrating functions, and so on. Everything I had learnt in my early undergraduate days was now being called on repeatedly, making it clear and intuitive in my mind. All of the fundamental theorems I had learned in my undergraduate days were now getting stretched, twisted and applied in all sorts of ways. This went a long way in strengthening my mathematical ability. I walked into industry not with a knowledge of the theorems, but a *mastery* of them.

I also found that when I picked up material on financial maths, I didn't err as it was all built from the same fundamental ideas. I was also able to find quick ways to do things in options trading; there are plenty of ghastly formulas jumping about (see here for a demo) and intuition (along with Taylor approximations) helped to cut through the noise.

CONVERSATION

This quality is a natural companion to the first. They both speak to the importance of being a *grounded and down-to-earth* mathematician. Even the best mathematicians in the world need to present their ideas for review.

If your brain is always being trained to bring mathematics into the realm of conversation, then you will find it easier to talk to selection panels, colleagues, shareholders, managers and so on. Provided you always, always speak with enthusiasm.

> "Companies need to make money to survive, and money comes from people"

Think about it from the eyes of a selection panel for an academic job. They have plenty of strong candidates, all of whom are strong mathematicians. But hey, Dr Bergers has the gift of the gab too — it is then likely that she will also be a strong teacher and a proficient collaborator, both of which mean great things for the department. And what's more, she is keen and ready to take on the role!

This is even more essential in industry. Companies need to make money to survive, and money comes from people, therefore you need to talk to people. Industry mathematicians work on very practical problems and being able to talk conversationally about mathematics gives the strong signal that you are grounded and able to solve real-world challenges.

When I walked into a trading company for an options trading job, I didn't even know what an option was (I also made the mistake of misspelling the company's name on my cover letter). But I told the interviewers, with conviction and enthusiasm, that I loved to learn new things and I wanted to do mathematics at a faster pace. They asked me to explain my PhD thesis in a minute (a standard question for any job) and I was ready for it. It is probable that your interviewers will not be as good at maths as you are; do not isolate them.

So how do we become better at talking about mathematics? There are many ways for students to do this:

- Write as much as you can. Every day! Keep a blog. Don't have any ideas? Maybe a *Theorem of the Week* blog where you write up the most interesting (or difficult!) thing you learnt all week with intuitive explanations, diagrams, examples, etc.

- Create a *problem-solving group* with other students. Every week you meet for to go through a couple of tricky Olympiad-style problems. Ask somebody in the maths department to help. Each week, a different student convenes the session. This is also a slick way to add to your problem-solving toolkit. I heartily recommend the book *Problem-Solving Strategies* by Arthur Engel for this endeavour.

- Create a *reading group* with other students. When I was an honours student, some of the PhD students were doing a reading course on *Introduction to Analytic Number Theory* by Tom Apostol. We would meet once a week to cover a new chapter and somebody had already been given the responsibility of condensing it down to a one-hour lecture. It was this reading course that inspired me to go into number theory.

- Become a tutor for a class you've already taken or for primary and high school students. This is invaluable training for learning how to explain maths to different ages and minds.

- Be involved in online forums such as StackExchange and Quora. Get a Discord group going with your friends where you can chat maths.

- If you're a PhD student, why not give the *3 Minute Thesis* competition a try? This runs at most Australian universities and is the ultimate test in condensing a slab of research into a slither. I had a go at this some years ago. There's a video on Youtube too.

Be creative. Come up with some other ways to write and talk about mathematics, which brings us neatly to the third quality a mathematician needs.

INITIATIVE

You will need to carve out your own mathematical career. As a student, you are always being set problems to do. At some point in your career, you will be pretty much on your own, although there will always be places to look for inspiration.

In maths, initiative is all about asking questions. Nothing should go unexamined. And asking questions is fairly easy; it just takes time and the willingness to tear yourself away from the doing of maths for a minute.

Here's an example of how initiative can work in academia. Let's say you're a number theorist and one day you come across Lagrange's four-square theorem in a textbook:

Theorem. *Every counting number can be written as the sum of four integer squares.*

To demonstrate the quality of clarity, it makes sense to pluck a few counting numbers out of the sky to test the theorem:

$$28 = 5^2 + 1^2 + 1^2 + 1^2$$

$$65 = 8^2 + 1^2 + 0^2 + 0^2$$

$$99 = 9^2 + 4^2 + 1^2 + 1^2$$

Note. *It would be good practice of the conversation quality to have a go at explaining the theorem to a non-mathematician.*

Now, let me demonstrate what I mean by initiative. Your mind should start buzzing. Of course, the theorem we are looking at was proven by Lagrange way back in 1770. This doesn't mean that it's the end of the line, however. These questions come to me immediately:

- How does one prove this? What is the quickest modern way? Can I come up with a better way?
- What if we use triangle numbers instead of square numbers?
- What if we use cube numbers instead of square numbers?
- What if we impose restrictions on the size of the squares?
- How many counting numbers can I make out of only three square numbers? Is it a positive proportion of them (e.g. 12.5%)?

All of these questions have been tackled already, because that's what mathematicians do. They ask new questions, especially if the initial problem is too hard. Consider the incredible amount of research surrounding the Riemann Hypothesis.

Riemann Hypothesis: *All non-trivial zeroes of the Riemann zeta-function have real part equal to 1/2.*

Most number theorists don't try to prove this one. It's a doozy. Instead, they have proposed other less insane problems to solve:

- Let's just assume that the hypothesis is true. What other things can we prove?
- What ramifications are there if the hypothesis is false?
- Can we at least prove that *a lot* of the non-trivial zeroes have real part equal to 1/2?
- Can we show that all of the zeroes are at least *pretty close* to having real part of 1/2.
- Can we prove the hypothesis for other functions?

Now, the working mathematician finds the question that optimises for interest and accessibility. This obviously takes a good deal of time working through the literature but it's part of the job.

Asking questions as above opens up the research opportunities for you. Just like that, there are so many new problems to work on.

Generating numerous questions on anything is also key to research and progress in industry. When I went into finance, where the end goal of much of the maths is to produce results, I would ask general questions such as these to find new problems:

- Can I make this part of the job easier/automatic?
- Can I make this code faster by using simpler functions or writing it differently?
- Is there a way I can visualise this dataset that will provide new insights?
- Is there a better cost function I should use in this analysis?

In short, ask lots of questions and challenge what's already laid out in front of you. Oodles of good maths can come from trying new approaches to old ideas.

Summary

Make sure to master the fundamentals of maths, specifically calculus, linear algebra, probability and statistics.
Practice talking and writing about maths as much as possible.
Create your own problems to work on by asking questions.

GET A MATHS JOB

Getting a maths job in industry requires the firm application of the following two steps:

Step 1. **Find maths job** → Step 2. **Get maths job.**

Each of these points will be discussed in firm detail but first I must indulge in a rant.

The industry job space is messy, and this is expected. You have a collection of companies looking for people that can come in and have immediate impact. A mathematician fresh off the conveyor belt might be disturbed by the sheer number of positions that ask for a working knowledge of querying SQL databases or proficiency in C++ and Python programming languages (along with R being a feather in the applicant's cap). Indeed, companies want people who are proficient in the programming language they use so they are able to hit the ground running. I think this is shortsighted; industry mathematicians should get hired on the qualities discussed earlier (clarity, conversation and initiative) in addition to the candidate's *potential* to tick off the things needed to perform the job in a suitable timeframe.

Here's a possible scenario. A company needs to fill a graduate position where the candidate will need the SQL language here and there. You have two applicants, Kate and Sam. Kate is an incredible mathematician; she was awarded the university medal; she is down-to-earth and great at explaining her ideas; she is a very hard worker and a strong programmer in the Python language. Sam was a below average student, prefers to work alone but can program reasonably well in SQL. Who would you pick? If you want somebody who is going to lift your company in the long run, you hire Kate. It would take her very little time to learn SQL and then given her academic strength it's also likely that she will eventually program in SQL to a better level than Sam. Kate is also clearly intelligent and driven, making her more likely to push advances in other areas.

Where is this rant going? Well, I think we would all be a lot better off if companies hired for the person and not for the skills. Good mathematicians will pick them up given a bit of time and perform better in the long run. Obviously, the world is not ideal, so mathematicians will need to bend a little as well in order to succeed. Hopefully, if you can impress your employer with your conversation, they will meet you in the middle. As such, I don't think you should be discouraged if you don't tick all of a company's boxes during the application. Address it and own it in your cover letter; tell them straight up that you have never coded in SQL before, but you are a whiz at Java and would work hard to get up to an acceptable level.

FIND MATHS JOB

It's time to give you a lesson that all hopeful applicants learn at some point. Go ahead and type the word *mathematician* into your favourite job search engine and hit search. It's not a fruitful endeavour. Most companies don't advertise for a mathematician; they need a trader or a data scientist. This is why it's helpful if you can establish early on the kind of maths you want to work on. This will allow you to hone in on specific employers without having to rewrite your cover letter many times.

Here are the main places where mathematicians work (I may have missed a few, but this should give you enough to start looking). If you type these titles into a job search engine you should have more luck.

Data Scientist/Engineer/Analyst

Data science is booming. Companies are in the habit of hoarding data and need specialists to process it, analyse it, and come up with useful insights. For example, this could help them improve and target their products more effectively. This could be a nice fit if you like searching for patterns in massive tables of chaos.

Foot in the door: Statistics and Programming at a basic level. There are scores of data science courses available online. Many of them are free as well. Hop onto Coursera, EdX or MIT OpenCourseWare to find a suitable course.

Machine Learning Engineer/Developer

People often think of machine learning as a specific area of data science where models are built that can *learn from the data*. Examples are everywhere: Netflix recommends you shows it *thinks* you will like, the Photos app on your phone can *recognise* your face in each photo, personal digital assistants like Siri and Alexa *understand* your requests and so on.

Foot in the door: Calculus, Statistics and Programming at a basic level. A lot of people start with data science before rolling into some machine learning algorithms. Liquet, Moka and Nazarathy have made an excellent machine learning course specifically for maths students which they delivered for the AMSI Summer School in January 2021. You can find all of their notes here plus all of their recorded lectures in the *Mathematical Engineering of Deep Learning* playlist on YouTube (username is *One on Epsilon*). You could do this course without doing any data science beforehand. Another very good option is the DeepLearning.AI course (I did this course myself), though this costs money and is not as mathematical as the one that was delivered at the AMSI Summer School.

Trader

If you like probability, betting and risk-taking, then there are plenty of trading roles out there. I went into options trading, in which I found plenty of maths to learn. Knowing a bit of data science and machine learning helps you along as well and prepares you for quantitative researcher roles if you're not that trigger-happy.

Foot in the door: The way into trading is usually through a graduate role; you could apply at most banks, but these days there are plenty of opportunities at "prop shops" such as Optiver (I worked as an options trader here for five years), IMC, Liquid, Tibra, Maven, Susquehanna, etc. The prop shops are a good choice as they are smaller companies so you know everyone you work with. Some of these companies have in-house training courses. To get a foot in the door at one of these places, you usually won't need any specific knowledge as they like to train you up themselves.

Risk Analyst

Risk analysts monitor positions at banks, funds and trading companies to make sure the book is within the acceptable risk appetite. You get to work closely with traders and also make the call on some of the larger positions (without having to be the one who pulls the trigger!). Probability and statistics are essential for this role, as well as a strong interest in trading.

Foot in the door: Similar to trading roles; there are plenty of graduate positions about.

Maths Teacher

Due to the shortage of maths teachers, you are likely to find a job easily if you choose this path. If you love teaching, you will be rewarded with the knowledge that you are making a difference to your students and hopefully educate some of the next generation of mathematicians.

Foot in the door: Usually a one-year Graduate Diploma in Education (or a two-year Masters) is enough for you to make the transition, though if you're keen you can have a look at the Teach for Australia program which gets you into a job quicker (you study for your Masters on the side). Most universities offer online options for the teaching degree.

Mathematician at Defence/ASD

I did my PhD in Canberra and I was astounded by the number of mathematicians who ended up working for Defence (many through the Australian Signals Directorate). Start with the Careers page at Defence Science and Technology Group and also check out the one at ASD. Not only do they have the graduate intake, but they also have Early Career Research and Post-Doctorate opportunities.

Foot in the door: Programming is definitely going to help you here, along with a course in codes and cryptography.

Biostatistician/Bioinformatician

This is another booming area. Biostatisticians are like data scientists for health-related data. You will need more specific training for this role involving understanding clinical trials and health surveys. Bioinformaticians have training in genetics and molecular biology and focus their statistical and programming knowledge on such. If you're interested in medicine and genetics, then this could be a nice field to bring your mathematical know-how to.

Foot in the door: There are quite a few courses and jobs popping up in this field these days (Google Master of Biostatistics and Master of Bioinformatics). Completing one of these courses seems to be the natural way to move into this field. However, there are other options such as the NSW Biostatistics Training Program.

Actuary / Actuarial Analyst

There has always been a bit of prestige around being an actuary. Most roles will require you to be a fellow of the Actuaries Institute (or at least to be working towards this). The focus is on the pricing and risk analysis of financial instruments, insurance products and businesses. The actuarial profession calls for strong enthusiasts of statistics, modelling and programming.

Foot in the door: You have to complete an approved degree at an approved university. Then there are additional exams to do also. See the Actuaries Institute webpage.Bioinformatics). Completing one of these courses seems to be the natural way to move into this field. However, there are other options such as the NSW Biostatistics Training Program.

Note: For a comprehensive collection of advertised jobs in mathematics, see AMSI MATHSADDS.

Summary

- There are plenty of jobs out there for mathematicians – you just need to know where to look!
- There is often preparation work involved to get job-ready. Find out what it is, write it down and get cracking. There is less work if you can identify what jobs will be the right fit for you.

GET MATHS JOB

Your teachers told you that *maths can take you anywhere*. This statement is *almost true*; there is some work we might need to get there. This is the part where some students struggle. After having become accustomed to formal structured learning, when faced with the openended task of, say, learning to program in Python, the lack of constraints seem to be damning to one's motivation. There are *hundreds* of free courses on Python, and some students get bogged down on which one to choose amongst other things.

However, learning to properly navigate and complete an open-ended task is one of the best ways you can practice and display the initiative we have talked about. Let's say you're a student and you've been told by some employers that your job prospects would be enhanced if you learnt Python. Ask them specifically what they would like you to know or go and find out yourself. Write a list of things that you are expected to do in the roles you are interested in. Maybe you come up with a list of 10 things; being able to learn basic Python so that you can do a couple of these things will greatly increase your prospects. You'll also find that a bit of momentum will take you a long way.

I can not emphasise enough how important it is for you to *build your own skills*. When faced with the choice of either being the person who moans that they were never told they needed to learn to program at university or teaching yourself how to program, you can be pretty certain that the latter choice is the one that is going to pay dividends.

On the other hand, *don't* be the person who needs to finish all the latest one-thousand-page textbooks on Python before they can even think about applying. That would be *too much* work.

At any rate, you will need to do some work to become job-ready, especially for a specific role such as biostatistician or actuary. Be sure you know the benchmark qualities of a mathematician in industry:

- Can solve problems in a programming language.
- Has a working knowledge of statistics.
- Strong work ethic especially for learning new things.

Indeed, if you want to get a maths job in industry, it is essential that you can program. If you are currently an undergraduate, you will want to enrol in a beginners programming course at your university. The language isn't very important, but as somebody who took courses on Java, C, Matlab and R during my studies, and then found Python years later, I would like to save you some time and advise you to use Python. It's simple and effective for a range of things from solving little problems to doing regression analyses, building neural networks, etc. It's a tidy and intuitive language and lots of companies use it.

Here is how you could go about learning Python to an introductory level:

1. Start with the free Python for Everybody course on Coursera. Just do the first course in the specialisation.

2. Solve the first 20 problems on Project Euler. Solve more if you feel like it.

Another strong option is to do the Udemy course 'Automate the Boring Stuff with Python'. This covers an introduction to Python but importantly gives you practical computing problems to use your knowledge for.

OK, nice work. Now the initiative kicks in. What sort of problems do you see yourself solving? You should now seek to create your own project to work on to further your Python skills. It also gives you something "real world" to show prospective employers; you can describe your project in your cover letter. At first, you might feel lost trying to find a project but it's important to stick with it. The world needs mathematicians that ask questions and can solve them without anybody holding their hands.

Here are a couple of examples of things I have turned to Python for:

- When I was house-hunting, I wanted to be able to estimate the fair value for the house I was looking at. I copied a bunch of sales data off of the web and analysed it using the pandas package in Python.

- My eldest daughter and I sometimes play the game Snap and I wanted to compute the expected number of snaps in a game. I basically just coded in the game, simulated it 100,000 times and took the average number of snaps.

After programming, statistics is important. Every job I listed involves some level of statistics. You begin with the key stuff. By the time I got to the end of my PhD, I started light, with Larry Gonick's *Cartoon Guide to Statistics* and Charles Wheelan's *Naked Statistics* before revising my course materials from first year.

Finally, the willingness to learn new things. If you get stuck, slam a vague description of it into Google and follow the threads. If everyone in your field is using some whiz-bang kind of neural network, then you had better get on it. One of the best parts of being a mathematician in industry is continuously getting to learn the new and exciting developments in your field and then applying them to your problems.

Summary

- If you don't know a programming language yet, learn Python.
- Statistics should be given the most weight as it is central to most industry jobs.
- You must be able to drive your own career.

FINAL REMARKS

Mathematicians are a lucky bunch. Not many people know what we do, so most of the time we are left alone to do it. It's such a pivotal moment in history, with the advent of deep learning and artificial intelligence. With just a bit of determination, you will get to work on interesting maths mostly on your own terms. There is not much more one can ask for.

Finally, the combination of white light and fifth-beer drowsiness has likely led to dreadful omissions and oversights. Feedback and questions may be forwarded to awdudek@gmail.com.

ADRIAN W. DUDEK

Adrian grew up in Perth and studied pure and applied mathematics at the University of Western Australia. In his honours year, he went along to the AMSI Summer School at La Trobe University and was delighted to spend time with like minds learning new mathematical things. After honours, he decided that prime numbers were cute little things and so moved to Canberra to learn more about them. Adrian recalls his PhD years as his best; he relished the academic freedom and learnt a great deal about prime numbers.

He attended the AMSI Winter School on Cryptography and this is where he had the revelation that academia and industry are not one-way-doors but different arenas for the doing of maths. He finished his PhD in number theory at the ANU in 2016 under the supervision of Dr Tim Trudgian before moving to Sydney to trade options at Optiver. He cites a fleeting attention span as the reason for the change, but an enjoyment of seeing maths in action kept him there. After five years on the trading floor, he shifted into his current Head of Academic Partnerships role at Optiver, and now works remotely from Mothar Mountain in Queensland with his wife, two daughters and son. He retains his joy for prime numbers and maths problems.