APPLYING TO OXFORD MATHEMATICS (UNDERGRADUATE)

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Contents

Date: April 25, 2024.

The table of contents should have red highlighted boxes as shown below. Those highlighted boxes are hyperlinks. There are various hyperlinks scattered throughout the document as well. Please download the pdf file and use a pdf file reader installed on your computer to read the file if you aren't seeing the highlighted boxes.

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Introduction

I shall mainly go through things about applying to Oxford that's specific to mathematics. You could refer to other resources for more general guides.

1. Knowing more

It's crucial to know more about what studying mathematics is like at Oxford. It certainly may seem daunting, but it may save you a lot more effort to spend some time really thinking about whether mathematics is the right subject for you. While it is possible to change subjects after you've arrived in Oxford, it's a rather lengthy process that's best to avoided. That said, it's impossible to fully predict whether you've picked the right degree!

1.1. **Course Choice.** I would heavily recommend at least looking into the syllabi of physics or computer science. Look into first year course options. Compare the courses that you would take. Look through the reading lists the first year courses provide. Compare how the books present the same material.

Think carefully about joint school courses. What first year courses are you gaining and losing? In Oxford, it's basically impossible for second years or above take first year (prelims) courses. While it is possible to self study courses over the summer, it's still much nicer to study courses during term time as you'd have tutorials from excellent tutors and exams to check your progress.

1.2. **More information.** Read the undergraduate handbooks for more information. You can take a look at the glossary for terms that are only used in Oxbridge.

1.3. **Mentality throughout the admissions process.** Considering how personal the teaching is at Oxford, I would imagine that throughout the admission process tutors are only interested in one question: whether they would want to teach you over the next two years. To answer this question for them, you would need to show a few things about yourself.

Firstly, you show that you're technically capable. The tutors need to know that they could start teaching you without spending too much time going over the basics.

Secondly, you show that you're interested in mathematics. Imagine being a tutor enthusiastically talking about their favourite bits of mathematics, only to find students waiting for the class to end! It would be tremendously frustrating.

Thirdly, you show that you are committed to mathematics. It's difficult to withstand studying mathematics all the time for four years. You have to show them that you're ready for such a commitment and wouldn't give up halfway.

Finally, you show that you could be changed for the better. It means that the tutor would be able to help you become better at mathematics through teaching. If the former could not be achieved then there would be no point in tutorials and classes!

To me, everything in the admission process is about testing one or more of those four aspects mentioned above. The personal statement demonstrates your interest and commitment, the admission test demonstrates your technical ability and the interview demonstrates whether you could be taught.

2. UCAS

2.1. **College Choice.** I would recommend basing college choice on scholarships / accommodation first. However if possible, do choose colleges that offer funding for activities that you may be interested in, such as summer research projects. It may be advantageous to choose a college with a variety of mathematics tutors.

3. Personal Statement

3.1. **Write concretely / Be mathematical.** Don't list what you've done without further elaboration, or make it look like a point-form CV. It's very easy and tempting to have the entire essay be peppered with "I've done X, got Y award" but such an essay simply doesn't reflect your mathematical ability or thinking in depth.

Make an effort to describe the mathematical content. If you say mathematics is abstract, what kind of mathematics have you encountered *that is* abstract? (e.g. the definition of a group or vector space?) If you say mathematics is full of rote memorisation of formulae, what formulae have you encountered that actually doesn't need to be memorised and has a nice explanation behind it? (e.g. integration by parts coming from chain rule, trigo formulae coming from Euler's identity …) If you say being the president of the mathematics society has made you a better mathematician, is there a concrete example? Did a fellow student ask you a mathematical question that provoked mathematical thought? Did the activities you organised enhance your mathematical understanding? If so, what exactly?

The tutors reading your essay are more than capable to understand any mathematics covered in the first year or two of the undergraduate syllabi. Your UCAS personal statement should be written with a professional, mathematical audience in mind. It is different from other essays you might write (e.g. for scholarships where the audience may be more general).

3.2. **Make it personal.** There are a lot of facts in mathematics. Knowing more facts in mathematics certainly improves the ability of a mathematician to a certain extent. As such it's natural to show that you do know a lot of mathematical facts in your personal statement, which you can do by writing that you've joined activity X, read book Y or got award Z.

However, the personal statement needs to be more personal than the facts that you know. How can one make facts "personal"?

3.2.1. *Order of Learning.* Picking up a textbook / set of lecture notes for linear algebra, you would realise there are a lot of ways of introducing linear algebra. You could start with systems of linear equations going to matrices, you could start with

vectors in the coordinate plane or you could start with the abstract definition of a vector space.

Similarly, detailing how you have gone from learning X to Y to Z may be quite interesting and unique to you! Explain the impacts of learning something before others. Maybe the things you've learnt before inspired you or gave you more examples or (unfortunately) limited your understanding.

3.2.2. *Alternative definitions / proofs.* A lot of definitions and theorems in mathematics have alternate ways of formulating them. For example for real sequences, a sequence is convergent if and only if it's Cauchy. Yet the exact definitions of Cauchy sequences and convergent sequences via epsilon-delta are quite different.

This is where personal preference comes in. You may find one definition more intuitive than others. Explaining why this is the case to you allows room for personal opinion. You could write how you've encountered one definition of a certain object and found it confusing until you met another definition. Again the emphasis should be on explaining why you felt that way instead of stating everything factually.

3.2.3. *Choice of examples.* If someone asked you an example of a vector space, what would you give? Would it be $\mathbb{R}^2$? $\mathbb{R}^3$? Solutions to linear differential equations?

In other words, What's the most natural example of a mathematical object to you and why? It would show what area of mathematics you are most familiar with and interested in.

4. Admission Test

You'd need to take that maths admission test. You'd need to register for it on top of UCAS and take it physically. You can find more information here.

4.1. **Do past papers.** Doing all the past papers is perhaps the best way to prepare. You should do some of them under timed conditions. However, doing some questions is always better than doing none at all, so don't force yourself to do every paper under timed conditions if you don't have the time for it. You should also check out the official MAT livestream. If you really want to do more exercise, do the STEP foundation modules. They are really fun and teach skills and ideas mostly relevant to MAT.

(By the way correction tape is not allowed in the MAT. Be used to using pens and crossing out wrong answers!)

4.2. **Use the previous subparts.** All the subparts of the question should be logically connected. If you get stuck, try to use the results you got from the previous subparts.

Even if you are sure something would work yet it doesn't use the previous subparts, you should still try to think of an alternative solution that uses them. It would usually be more elegant and less time-consuming.

4.3. **Be thorough.** Every keyword/condition that appears in the question should be mentioned/copied at least once in your answer. You should also clearly state the results you've proved in the previous parts, and why they are applicable to your situation.

Doing so helps you realise whether you have used all of the information given, and lets the marker know that you are rigorously answering the question.

Some questions (Usually Q5) have a lot of cases to consider. You need to be very careful about them as there are often exceptional cases.

4.4. **Use intuition.** While there are exceptions, most questions could usually be answered without many steps. If you find yourself painfully expanding terms, you are probably not noticing something you should've. This is especially important in graph questions. Usually, you need to spot some rigid transformation.

4.5. **Think like the marker.** Take a look at the mathematics homework your friends submit. What work do you like to mark?

Make your work as friendly to the marker as possible! Refer to 5.4.3, 5.4.4 for advice on clear communication in your writing.

5. Interviews

Oxford Mathematics Interviews may feel daunting. Beyond the basic format of the interviews, here are some of my advice on tackling them.

5.1. **Goals.** There are a few things you want to achieve through the interview.

Firstly, you have to show that you can be taught. You need to show that you can improve from your tutor's teaching and that it's satisfying to teach you.

This means that communication with the tutors is crucial. You should place great care on how you communicate with your tutor: How you explain yourself and how you respond to your tutors.

I find this to be an often overlooked point. Think like a tutor interviewing applicants. You would surely pick an applicant who is satisfying to teach (i.e. showing improvement upon your teaching / responsive to your comments) but struggles initially than one who speeds through all the interview questions accurately but doesn't respond well to your teaching. Who knows if the later applicant ends up struggling at some point in their studies and now there's nothing you can do to help them?

Secondly and perhaps more obviously, you would like to show that you have the ability to do mathematics. Even if you're very teachable it might be impossible to bring you up to speed during the intense terms at Oxford. You need to show that you have sufficient mathematical intuition and you have the necessary skills to put intuition into words through technical terms and rigorous / logical explanation.

Mathematical intuition and rigour are both learnable skills. Intuition comes from practice and experience. When someone sees a problem and is able to tackle it quickly, most often it's because they have seen a variation of that problem somewhere and can alter the techniques slightly and apply it to this new problem. If you have got through the MAT and have gotten an interview offer, be confident in your intuition! You should have seen enough problems and have done enough mathematics to be able to have a lot of ideas on a wide range of mathematical problems.

Rigour comes from experience doing mathematics rigorously. This may be a little bit harder to obtain through secondary school or elementary olympiad mathematics alone. I would recommend reading some basic books on mathematical logic or a bit of analysis and linear algebra just to get a taste of how mathematicians generally write and construct mathematical arguments logically.

Thirdly, show that you're enthusiastic! Tutors would like to see if you have the tremendous enthusiasm needed to get through 4 years of constant mathematics. It's much more satisfying to teach someone who's enthusiastic anyways.

Finally, show that you're persistent and flexible. Show that you're persistent in advancing your mathematical understanding and flexible enough to consider any idea or method in pursuing that goal.

All in all, think like a tutor interviewing yourself. What qualities would you be looking out for if you were a tutor?

5.2. **Before the interview.**

5.2.1. *Recite common identities beforehand.* Try to recite some of the common identities (calculus, trigonometry …) before the interview. It would be unfortunate if you had to waste valuable time deducing them on the spot.

5.2.2. *Arrange mock interview.* Try asking your teachers, or alumni of your secondary school who have had an Oxbridge interview before to give you a mock interview.

In addition, try practising explaining mathematics to your classmates. Take great care ensuring that they understand your argument. The priority should be on being as clear as possible.

5.3. **Mentality during the interview.**

5.3.1. *Be enthusiastic, persistent, flexible and confident.* Be enthusiastic about the interview question! Even if the questions seems trivial, you could think about deeper insights / ways to generalise the problem whilst you're answering it which should keep you busy and interested in what you're doing. Doing so generally helps you in the follow-up questions and is related to my next point on generalising your thinking.

Be persistent and flexible! Don't give up understanding the interview questions even if you know the interview is going to end or that you're going to move on to another question. Be persistent in complicated equations and calculations and not be afraid of them. However, you should also be flexible. If your methods aren't working, don't be afraid of starting over and attacking the problem with a different angle. Be open to criticism and ideas your tutors suggest. In a way, flexibility is a manifestation of your persistence in gaining deeper mathematical understanding.

Persistence and flexibility can be in contradiction as sometimes you may be unsure if you should keep going with your methods despite it seeming ugly or change your methods entirely. At the end of the day, you need to be confident in yourself regardless of your choice. Give every idea your best shot before considering others.

5.3.2. *Generalise your thinking.* The first question they ask you might be very easy. While you are answering it, think about the complications they could throw at you. If they were asking about the $n = 1$ case, what about $n = 2, 3...$? Could you figure out a general solution?

A corollary of the above is that you should not rely on brute force for simple questions. Such a strategy would not work for more complicated cases and it doesn't reflect well on your mathematical thinking.

5.3.3. *Connect the subparts.* Previous subparts should aid you in solving the full question, just like MAT. Whenever you're stuck or confused, try and think about how the previous parts of the question could connect together.

5.4. **Explaining yourself.** If you think of the interview as a process of communicating with your tutors (instead of just solving a mathematical problem), you're generally either explaining what's going in your mind or responding to what your tutor has said.

As such, the first step to effective communication is to explain yourself.

5.4.1. *Talk out loud.* There are only so many ways you could let your tutor understand you, and you should use all the ways at your disposal towards achieving that goal! Write on your Miro board / piece of paper. Talk about what you're doing. The worst thing would be to sit in silence and not write anything. Your tutors aren't mind readers and they would not understand what you're going through. Remember that your ultimate goal is to communicate and not only to complete the mathematical problem presented to you.

Make sure you keep talking. In reality, talking is a brilliant way of mathematical communication. While we are used to writing as the main way of mathematical communication through exams and homework, writing everything out often takes up too much time and it's hard to convey intuition through mathematical writing alone. Long sentences are better spoken than written.

You could talk about what you're doing right now. What is the immediate goal of what you're doing right now? What results do you expect to show up? Why is it relevant to the problem at hand? When you introduce a variable, what is it supposed to represent? Why is it relevant?

You could also talk about your strategy for tackling the problem. Why do you think this strategy would work? Is it because it was used in the previous problem / some other problems you have seen before?

Explaining your overarching strategy is especially important if you are unsure whether you have the right strategy. They would usually say something to indicate whether you're on the right track. If they affirm your plan, then great! You can focus on the calculations / nuts and bolts of the argument. If they dispute it, then at least you didn't waste time exploring a dead end.

The tutors may also be more lenient on your careless mistakes if they know that you have the right ideas in mind. If you didn't talk about your plans, they may think that you have had the entirely wrong idea in the first place.

5.4.2. *What if you're stuck?* You may immediately get stuck when you first hear the problem. It's important to give yourself some time to process what's been asked. You should almost always write down important parts of the question carefully and slowly to ensure you got the right question in mind and to give you some time to think.

After spending a bit of time thinking (3 seconds), you should try and say some of your initial ideas on the problem, or what methods you would like to use to tackle the problem, even if they are not polished. You could speak in broad terms / talk about strategies, but you should avoid saying something concrete if it's not thought through. Muttering concrete statements without much justification may reflect that you're blindly guessing which does not reflect well on your mathematical ability.

For example, if it's a graph sketching question, you can say that you would try and find the intercepts by writing down the relevant equations, but don't immediately guess that the intercepts are say positive or negative. If you find those equations too tricky to solve explicitly, you could mention some observations, or simply say this seems difficult and move on to other aspects that you can consider like derivatives or asymptotic behaviour.

You could also consider simpler problems which often reveal insight into the problem you're dealing with. For example, if you're asked to sketch $\sin(1/x)$, try plotting $\sin(x)$ and $1/x$ carefully and see if it helps. You could also segment the problem, such as sketching the graph at particular intervals first. You could also find approximation / bounds to the graph you're asked to sketch. For example, $-1 \leq \sin(1/x) \leq 1$ simply from the properties of the sine function.

Still, you should not dwell on low-hanging fruits for too long. For example, you shouldn't find the values of the graph at $x = 1, 2, 3, \ldots$ and brute force your way. If you recognize that there's a complicated but important idea that you have to try and understand, give it your best go! It shows that you have an awareness of what's important and that you have a strategy in mind. The tutor would see you struggle but at least you would be on the right track and they may offer some help.

You should also constantly explain why you think you're stuck. Why are your methods not working? What results are you expecting? Why do you think they are not showing up? What's the main difficulty of the problem?

Since this is something you would constantly face in lectures / problem sheets / tutorials, tutors are eager to see if you're able to tackle difficulties. Remember that getting stuck is as an opportunity to display your problem-solving skills.

5.4.3. *Explain in detail but do not overdo it.* When you're explaining your workings, take care in explaining both your intuition and the technical know-how. Remember to do both and not only one of them.

For example, if you are asked to find the maximum of a function over some interval, you could first briefly that the maximum would be located at a point that has a tangent line with slope 0, otherwise you could "move" slightly to the left or right to get a higher value. Alternatively, the maximum could be at the endpoints of the interval. (That's the intuition). Then you could explain that we could calculate the derivative, which is the slope of the tangent line, and briefly explain the chain / product rules if they are used (That's the rigour)

You should also use technical terminology if possible, such as "tending to", "asymptotes", "periodicity". You should give both an intuitive explanation of why they're relevant and a rigorous definition of the definitions.

However, don't explain things for the sake of explaining it / seeming more rigorous. Your time in the interview is limited and you should spend it wisely. For example, you don't need to explain or write out all the steps taken in basic algebraic manipulation. Again, long sentences are better spoken than written.

As another example, consider proofs by induction. It's unnecessary to write out the formalities required in an exam setting. You could just write "Base case:" and "$n \geq 1$:"and it would generally suffice. You should however explain why you're using induction in the first place (You want to show something is true for all positive integers and that there's a connection between the nth and the $n + 1$th case?)

5.4.4. *Write neatly.* Writing stuff clearly doesn't take a lot more time but makes your content far more readable to you and the tutor. You would actually trust what you've written down instead of re-doing it all if you have found a mistake.

Write from left to right, from top to bottom. Don't make insertions all over the place for the sake of convenience. If you need to cross something out, you might as well write it all over again for the sake of clarity.

Keep your font size consistent. In Miro you can check the scale of your board (bottom left corner) and ensure it's always around 100%. You could try using more lined paper to train up that consistency even in blank paper.

If they ask you to draw a graph, take some time drawing your cartesian plane! The axes should be straight lines with appropriate ticks and arrows.

Writing out basic arithmetic (addition / multiplication / division of two-digit numbers) quickly instead of doing it in your head is generally a good idea as well. It ensures you don't make mistakes while not taking up much time.

If possible, use tables. They are often the clearest way to display information Here are some examples

No. of sides	Angle sum
3	$180 \times (3-1) = 360$
4	$180 \times (4-1) = 540$

n	$f(n) = n(n+1)/2$	$f(n+1) - f(n)$
1	$1 \times 2/2 = 1$	2-1 = 1
2	$2 \times 3/2 = 3$	3-2 = 2

In conclusion, time is limited in an interview. Even if you know the full solution to a problem, you may only have a few minutes to explain it or else there might not be time for other / more advanced questions. Find a balance between accuracy, ease of understanding and time taken. Find what works best for you!

5.5. **Listening and Responding.** The second step to effective communication is to listen and respond well to the tutors.

5.5.1. *Stop and Listen.* Whenever your tutor says something, stop and listen! The most frustrating feeling is to be ignored. Try to understand what they're saying, and try as hard as possible to come up with an appropriate response.

You should also avoid interjecting. It's best to let the tutor finish their sentences (which are usually short anyway) so that you have more information to work with.

There are generally a few scenarios that play out when your tutor says something to you.

5.5.2. *You don't understand what they said.* If it's due to some specific terms that they used, don't be afraid to ask for definitions! It's perfectly acceptable to forget / not know some mathematical terminology, especially if you're an international student. You can also make an educated guess. Regardless of if you're right or not it shows that you have thought about it and have a rough idea of the mathematical concepts at play. The tutor could give you a better answer if they know what you already know.

If the idea they're suggesting is too complicated, try to paraphrase and internalise what they have said first. Try and perform the most basic idea they have given you. It could be writing out an equation, setting up some variables or drawing a graph. Do the most that you can. It shows what you currently understand (you could be closer than you think!) and it would get you closer to the final solution.

5.5.3. *They asked why you are doing this or that.* Be calm and confident! Don't immediately think that you're wrong. It may be due to a lack of explanation and the tutors want to know that you really know what you're doing. Slow down and explain more about your goals / strategy.

5.5.4. *They are not convinced by your explanation or suggested that you're on the wrong track.* It may feel very distressing to be wrong. As such the most important thing is to keep your cool, don't get immediately defensive about your methods. Take at least a few seconds to organise your thoughts.

Then, look out for any careless mistakes/oversights. If you spot some, take your time to explain and correct them. It's important to take your time so that the tutors can see that you truly understand what you got wrong. It reflects poorly on you if you hastily make some corrections only to be wrong again. To explain yourself effectively you must be confident in yourself.

Also, consider whether there was any miscommunication. Sometimes the tutors might have lost your train of thought. If you are certain that you were right, explain more about the exact point of confusion your tutors had. You could start over your argument carefully in hopes of finding any overlooked mistakes.

If they still insist that you are wrong or should try something else, it's very important to be flexible. Don't be fixated on the method that you've been using. Don't be afraid to start over completely and attack the problem from a different angle.

5.6. **Conclusion.** The interview is very much a communication process. Just as you communicate with your tutors through written work, it's important to excel at communicating verbally in tutorials as well. Think about how you communicate effectively with others and apply those lessons in the interview!

While a lot of the qualities I've mentioned may seem like an act, those qualities are genuinely needed to succeed at mathematics. Try to internalise those qualities so that the interview process not only helps you get into Oxford but also helps you become a better mathematician.

Conclusion

A good book to read further for general advice would be "A Mathematician's Survival Guide" by Steven G. Krantz. You may also find inspiration from "I want to be a mathematician" by Paul R. Halmos.

Don't let university applications get into your head too much! Ultimately, mathematics should be the thing that you pursue the most. Don't let your interest in mathematics die out or all would be pointless!

> *"Do not dwell in the past, do not dream of the future, concentrate the mind on the present moment" — Buddha*