

## Handout: Why do we need Ethics in Mathematics?

*Notes to Instructor:* This handout is a version of a handout that we distributed at a mathematics departmental open day for prospective students. It is written with the intention to be fun to read and to make students aware of where modern mathematics is used. It serves well as a leisurely supplementary reading for students if you decide to use some of the example sheet questions in this document.

**Have you ever thought about the ethical issues that mathematicians and people using mathematics might encounter? Have you ever thought about all those issues that are specific and peculiar to mathematics?**

Since primitive humans first began to use language and organise themselves socially, they have also counted and used simple arithmetic. It is a way of talking about and knowing about the world that is as much a part of what it is to be human as anything else that we might characterise as being an essential part of being human. Elementary mathematics – arithmetic, simple geometry, and the logic of problem solving have always been part of human activities and forms of knowledge of almost all human societies. But in the 21st century things are a bit different. High-end mathematics done by highly trained professional mathematicians is ubiquitous, and is unavoidable in a digital world. Most of the technology around us does not just use elementary arithmetic, algebra, and geometry – it often uses the most cutting-edge mathematics, the products of recent research and of the most technically sophisticated and abstract mathematics that humanity has produced. Mathematicians seem to be taking over the world, except that nobody has noticed. For example:

- The global financial markets are run by computer programmes that use mathematical models and mathematical analysis of financial products and markets. Modern financial mathematics is cutting-edge, highly developed, sometimes Nobel Prize winning and seriously hard. When the models fail, the economic consequences can be disastrous. A lot of mathematicians go and work for financial institutions, developing tools that come straight from research mathematics.
- The mathematics that keeps an aeroplane in the sky and brings you to your holiday destination is breathtakingly complex. Airlines optimise over passenger fares, fuel consumption, supply and demand of seats, and the logistics of moving aircraft, staff, hangar space, repairs and spares, food, fuel costs, as well as a thousand other things using computer-run optimisation software. Doing so requires data mining, multi-variable analysis and custom-made, sophisticated mathematical algorithms that only professional mathematicians can construct. And when they go wrong, aeroplanes don't fly.
- Tomorrow's weather predictions and models of global climate change both require mathematical methods and massive multiple-equation-solving techniques that were unimaginable in the 1950s. And, as you know, they still will get the weather wrong when you organise a barbeque for Saturday afternoon. By the way, supermarkets will automatically adjust their assortment of barbeque meats like beef burgers, sausages, and chicken (and therefore the whole supply chain) in real-time based on mathematical algorithms, data mining, and those weather predictions. Even your Saturday afternoon barbeque relies on unbelievably complex modern mathematics.
- From the mathematics behind the physics of the new and super-bright high-resolution flat screen on your mobile, to the way your phone signal jumps seamlessly from mast to

most as you move around, to the CPU chip in your phone and the encryption (or not) on your phone and who can break that encryption, your mobile phone represents hundreds of thousands, perhaps millions of mathematician-hours. So when you arrange your barbeque, you are doing it on the back of a vast amount of PhD (and beyond) level mathematics. How many of today's undergraduates will be developing the mathematics used in the next big high-tech thing?

A hundred years ago, even 70 years ago, mathematicians could get away with thinking that mathematics was value free and pure and removed from any ethical question or issues of social responsibility. But today mathematicians are amongst the most powerful and socially significant professional groups in society today. They play a part in everything we do (including the photocopier that printed this page). Don't we need to make all mathematics conscious of their particular power and social responsibilities?

This doesn't mean don't do mathematics (any more than ethical issues mean you shouldn't do medicine, or law, or physics, or computer science, or AI ...), but it does mean we need to make everyone in the community of (aspiring) mathematicians (that's you, by the way) aware that mathematics, too, exists in a socially responsible and ethical world and that there are very special issues and problems that only mathematicians can see and think about.

Mathematics can be a great tool for good – and it is, of course; admit it: you couldn't live without your smartphone or laptop, or holidays in the sun, or your pension fund. But like any powerful tool, mathematics can also be used for ill, and there are enough examples of it around us to be very concerned. Every professional and practicing mathematician needs to be sensitive to the specific ethical problems raised by mathematics. Every mathematics student needs to think about it, too.

That's why we have designed mathematical exercises that incorporate some form of ethical teaching, or lessons, into the mathematics. These questions might feel a bit different at first, but we urge you to come at them with an open mind. They are intellectually stimulating and quite challenging, and a lot of fun!