Mathematics. Trust me. It's important in your life

Who uses calculus? You do. Every day. Dr Ron Sandland celebrates the International Year of the Mathematics of Planet Earth.

By Ron Sandland

The American writer Jodi Picoult was invited to contribute to *Dear Me*, in which she wrote a letter to her younger 16-year old self. It contains some very warm and witty advice, but I was particularly struck by her fourth recommendation; "Calculus. Trust me. You will never use it."

The breadth of applications of mathematics down the centuries has been profound *(Source: ragsac/iStockphoto)*

While I can quite believe that Ms Picoult seldom (OK, never) sits down to solve a differential equation, she is probably unaware of just how much calculus and other areas of advanced mathematics affect her daily life.

For example, I used Google to track down Ms Picoult's quote. Google uses sophisticated mathematical and statistical algorithms to search for the information you need. Amazon is increasing its stretch as a retailer by linking its customers' preferences across a range of different product areas and presenting tantalising recommendations to its users.

How does Facebook find friends for you? How do you discover the links you want on Twitter? These are all based on proprietary algorithms developed by mathematicians and computer scientists. And the effects have been staggering. They have altered the way society works with information about just about everything available at the touch of a smart phone.

The market value of Google, Amazon, Facebook and Twitter, all built on intellectual property based on mathematical algorithms, is not much short of half a trillion dollars at current market values. Their algorithms have created value roughly equivalent to BHP, RioTinto and CBA combined!

And, in passing, the technology that underpinned CSIRO's wireless LAN patent that enables billions of devices such as smart phones, tablets and computers to connect wirelessly came out of CSIRO's pioneering work in radioastronomy. In CSIRO's words:

> "That work involved complex mathematics known as 'fast Fourier transforms' as well as detailed knowledge about radio waves and their behaviour in different environments."

Fourier transforms are a discovery from harmonic analysis, itself an advanced branch of calculus. In fact our daily lives have been deeply touched by calculus.

^ to top (#top)

Algorithms are amazing

When it comes to the mathematics of planet earth, one of the most striking examples of mathematics in action has been the development of Google Maps, which uses advanced imaging algorithms to enable us to find places, directions, zoom in and out, change the level of detail, and find a restaurant we'd like to dine at.

Australia is, at the time of writing, in the midst of a bushfire crisis of apocalyptic proportions. And I have been distracted because my granddaughter is staying with her father in rural New South Wales. Google Earth has enabled me to follow exactly where the fires are burning, which I've been able to marry with the

descriptive information provided by the Rural Fire Service to determine her safety at any time. Having access to this information has almost certainly saved lives.

With the widespread availability of laptops, tablets and smart phones, it is often overlooked that their smartness doesn't just come from their engineering: it comes from the algorithms which they can access to provide the information we need. And algorithms are step-by-step procedures to enable mathematical formulae to be calculated or logical tasks to be undertaken.

^ to top (#top)

Weather forecasts modelled on maths

But let's return to the bushfire catastrophe to which I referred earlier. Tuesday 9 January was Australia's hottest day since records began (averaged over the nation). This clearly came as no surprise to the Bureau of Meteorology spokespeople who were interviewed by the media. They have been able to predict weather more and more accurately on a finer and finer scale in recent times. This has come about as a result of many factors.

Obviously the advent of faster and more powerful computers has had a major part to play. Similarly, the development of sophisticated sensors has provided the bureau with enormous volumes of data which they can integrate into sophisticated mathematical models, themselves subject to continuous refinement as they are able to explore more and more deeply the complex systems that produce weather patterns. And in gaining a deeper understanding of the physical, chemical and ecological processes that control our weather, meteorologists are able to build complex systems of linked differential equations (Sorry Jodi, that's calculus!) to describe and predict our weather patterns.

The great statistician George Box was fond of saying, 'All models are wrong, but some are useful'. We're all aware that sometimes the Bureau of Meteorology's forecasts are slightly off the mark, but any objective critic would have seen that the accuracy of weather forecasts have improved dramatically over the past decade.

George Box's primary criterion of usefulness is the ability of models to predict the future. The improvement in our ability to predict the weather has come about through a virtuous cycle of faster and more powerful computers, the ability to capture what is often described as a tsunami of data relevant to weather and climate, refinement of the science that underpins the models (in the best traditions of scientific method), and increasingly sophisticated mathematically-based methods for analysing the data, integrating into the models, linking the resulting equations and solving them.

It is worthy of more than a passing note to say that when climate scientists take the models they have now and use them retrospectively from a decade ago the resulting predictions for the next ten years (and of course we now know exactly what has happened) are breathtakingly accurate.

^ to top (#top)

Celebrate calculus in 2013

The breadth of applications of mathematics down the centuries has been profound. The inventor of calculus was none other than Sir Isaac Newton, whose other discoveries, such as his laws of motion and gravity, changed forever the way we have been able to understand how the world works.

Mathematics is deeply involved in bioinformatics, which is vital in modern health research, to understanding how complex ecosystems work and, through statistical science, is providing the tools to make sense of the deluge of data that is changing what we can know and predict about almost every aspect of our lives.

If we keep this in mind and acknowledge the fact that most of the general population are of a similar opinion to Ms Picoult, it seems that greater education is needed to rectify this misconception.

It is fitting that 2013 marks the International Year of the Mathematics of Planet Earth (http://www.MoPE.org.au) . A year designed to broadcast this loud and proud. The Australian launch of the International Year of Mathematics of Planet Earth will take place on 29 January with a Simons Foundation public lecture by Professor Simon Levin from Princeton University. Professor Levin will

discuss the challenge of sustainability and the promise of mathematics.

One uses calculus after all.**About the author:Dr Ron Sandland OA** is a statistician. He became deputy chief executive of CSIRO in 1999 and was awarded the CSIRO Medal for Lifetime Achievement in 2006. He was president of the Statistical Society of Australia from 1993 to 1995 and awarded honorary life membership in 1998. He is currently chair of the Australian Mathematical Sciences Board, the Steering Committee of the Australian National Data Service, and the Advisory Board of the Australian Centre of Excellence in Risk Analysis. He was awarded the Order of Australia in 2007.

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