Kayaking on a waterfall

Editorial

Let me start by congratulating Professor Chris Linton on his recent appointment as IMA President and wishing him well during his term in office: the IMA will undoubtedly prosper under his leadership. His predecessor, Professor Dame Celia Hoyles, was an excellent president who achieved much over the past two years.

Among her many contributions, Celia was guest editor with Professor Richard Noss for December's special issue of *Mathematics Today* on the theme of education, surely one of our most important professions. I hope that you enjoyed reading the wide selection of entertaining articles by international authors, which clearly demonstrate the fluidity of mathematics and the adaptability of teaching to incorporate new technology as a means of enthusing and inspiring our students. For those interested, IMA Councillor and former Honorary Secretary, Professor Nigel Steele, and his colleague Matthew Bulmer (NCTL) will present a talk on *Training Mathematics Teachers* at the Mathematics 2016 conference in London on 17 March.

I chose the word *fluidity* carefully in the last paragraph, as December also saw some horrendous flooding throughout the UK. In Cumbria, rivers and lakes consumed farms, villages and towns, leading to the ruin of homes, businesses and vehicles, destruction of paths, bridges and roads, loss of livestock and closure of schools. Even the historic city of York was badly affected. Flooding of this sort has, of course, devastated other counties and countries in recent years, though I encountered this particular bout on an annual winter hiking trip to the Lake District in pursuit of the Wainwright summits. Driving through a 100 metre ford, that is effectively a waterfall, along the west bank of Thirlmere at the base of High Seat and Ullscarf is a terrifying experience.

Historical records were broken yet again, including the creation of England's highest waterfall at Malham Cove in the Yorkshire Dales, with an impressive drop of 80 metres albeit for one day only. Local knowledge suggests that centuries have passed since water last poured over these imposing limestone cliffs. Admittedly, this is insignificant compared to the massive waterfalls in Africa, North and South America, and other mountainous regions, but is nonetheless dramatic. Thankfully, recently installed flood defences did alleviate some of the damage. The investigations and recommendations of mathematicians such as Coles and Tawn [1] helped to secure these welcome improvements and will surely lead to future revisions based on updated predictions. Nevertheless, the army, rescue services and local volunteers in Cumbria made full use of rigid-inflatable and rowing boats to navigate the high streets!

All this talk of water reminds me of an amazing experience that I had several years ago. As part of a Day Skipper sailing course, I was fortunate enough to be at the helm of a yacht off the beautiful Pembrokeshire coast in south-west Wales, attempting a delightful passage across St Brides Bay from Skomer Island in the south to Ramsey Island in the north. Of course, navigation has long appealed to mathematicians, as evidenced in the recent article by Stansfield [2]. I now relished the opportunity to put my rudimentary navigational skills into practice. Although these islands host wonderful wildlife including Manx shearwaters, Atlantic puffins and grey seals, they also host some treacherous seas including fierce tidal races at Jack Sound and The Bitches, and choppy waves at Wildgoose Race. My experienced instructor decided instead that we should voyage through Little Sound, which had to be timed to perfection so that we passed through at slack water.

The crew and I thankfully completed the journey without harm. However, the amazing experience to which I refer occurred somewhere along this route, when some talented and daring paddlers brazenly stood upright upon their kayaks, making the most of a strong current and an incredible standing wave that steadied their boats sufficiently to support ridiculously elevated centres of gravity. Although I own a kayak and occasionally enjoy a paddle, I could not stand on the boat in still water and would certainly not attempt to do so at sea. Perhaps you have seen or experienced something similar, in which case I would be delighted to hear from you.

David Ball and I were discussing tides and currents at an IMA branch meeting last year, as a result of which he kindly gave me a fabulous book by Tricker about the study of waves on water [3]. Although the publishers are now better known for romantic novels, this is a superb introductory academic text on the fluid dynamics of water in rivers, lakes and oceans. One topic that this book addresses concerns bores, which are counter-intuitively of great interest. Bores are regular and tremendous surges of water that progress up river estuaries in advance of high tides under special conditions. The author notes that bores are caused by a narrowing of the channel or a rise in the riverbed and develops mathematical models to predict the occurrence, heights and velocities of tidal bores.

My particular interest stems from conversations with a neighbour, a casual fisherman, who was aware that this phenomenon exists commonly in local rivers, including the Kent, Lune, Ribble and Mersey. Many years ago, one of my father's friends was lost in quicksand on Morecambe Bay, where the tide is known colloquially to 'race in faster than a horse can gallop'. The largest bore in England occurs on the River Severn and flows for several miles upstream. It can reach two metres high and travel at about ten miles per hour, offering great fun for skilled surfers. However, the world's largest bore is apparently on the Qiantang River in China. It can reach nine metres high and travel at about 25 miles per hour. Tricker shows photographs of a spectacular bore called Le Mascaret on the Seine in France, though subsequent dredging has dramatically reduced this effect. Witnessing even a small bore gives a slight insight into the potentially awful consequences of a flood or far more destructive tsunami.

Another fascinating observation that this book makes concerns the existence of amphidromic points at sea. Apparently, the Severn Estuary mentioned above has the third largest tidal range in the world, beaten only by two bays in eastern Canada. However, an amphidromic point occupies the other extreme, where there is no tidal range. Nevertheless, the water level varies around such a tidal node and waves constantly rotate around it. According to my guide, there are exactly three amphidromic points in the North Sea, one just off the coast of southern Norway, one off Denmark and the third midway between Suffolk and the Netherlands. Of course, measuring tidal variation at sea is not an easy task: who wants to wait for a perfectly calm sea and then bob about for 12 hours and 25 minutes, avoiding drift and recording depths?

Points of stability stir another memory. As a maths student at Loughborough University during the last millennium, I attended a super course on astrodynamics, which considered the fascinating properties of satellites and orbits. The teacher, Professor Jerry Griffiths, presented the algebraic derivations behind the existence and locations of the Lagrangian points. These are exactly five points in space at which a small orbiting body affected only by the gravitational pull of two large orbiting bodies can maintain a stable position relative to them. In the Earth-Moon system, the Lagrangian points have practical implications for communications, observatories and depots.

Stable curves, or contours of constant height, depth, temperature and pressure, are well known to navigators and meteorologists, and here we have examples of stable points that exist naturally in two and three dimensions. The temptation is now to discuss singularities in other contexts, though this must remain a topic for another day. We have some interesting features in this issue of *Mathematics Today*, including the ECM Catherine Richards prize winning article (page 20), pancakes, escalators and several historical features, so I hope that you find them useful and entertaining.

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References

1 Coles, S.G. and Tawn, J.A. (1990) Statistics of coastal flood prevention, *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, vol. 332, no. 1627, pp. 457–476.

2 Stansfield, E.V. (2014) Part II – Navigation, *Mathematics Today*, vol. 50, no. 3, pp. 148–153.

3 Tricker, R.A.R. (1964) *Bores, Breakers, Waves and Wakes*, London: Mills & Boon.

Iguazu waterfalls in Argentina
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