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Jobs in Mathematics

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The following ad appeared in *The Australian* on 25 March 2006:

> **Hedge Fund Opportunities**
> **Mathematics, Statistics, Astrophysics or related fields**
> **Melbourne CBD**
>
> The Portland House Group Pty. Ltd. is one of Australia's largest Private Funds Management Groups. It operates on a collegial cultural with an open flow of ideas.
>
> The Group is seeking to expand its activities and is seeking applications from highly skilled academics who may be looking for new opportunities in the following different roles. (Experience in financial markets is not a pre-requisite).
>
> **Research**
>
> PhD's in mathematics, statistics, astrophysics or related fields, with a focus on prediction, cost modelling, risk modelling, betting algorithms, and simulation.
> . . .
> These are new roles which will be intellectually challenging for the candidate with enthusiasm and imagination. Salary is negotiable . . .

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There are some interesting aspects to the ad. It asks for people smart in mathematics, with a proven record of high-powered research. It doesn't care if they have been trained strictly in mathematics or in some related science like astrophysics. Nor does it care if the candidate has had experience in the particular field in which the job lies, in this case finance. The reason in both cases lies in the nature of mathematical skill — it is a general-purpose, transferable skill in the solving of quantitative problems. If someone learns it in one field, they have the ability to apply it to another, because complex systems are in some sense all the same.

We mathematicians always knew that, and we kept telling anyone who would listen. We were a little surprised, all the same, to find cashed-up employers like hedge funds agreeing with us and putting their money where their mouths were. We have even found some willing to pay us to train more mathematicians in their area. The software company SAS and the Commonwealth Bank have just jointly provided sponsorship to allow the UNSW School of Mathematics and Statistics to set up Australia's first degree program in Quantitative Risk, that is, the statistics of how banks manage risks.

Mathematics has both Platonist and Aristotelian aspects. The Platonist aspect, perhaps too dominant in school mathematics, concerns the abstract 'world of the forms', as Plato put it. Numbers, formulas, perfect shapes, proofs — those things are, according to Plato, beings in another world which we access through a mysterious faculty of intuition. Doing mathematics does often feel like that, since a proof that one really understands gives what feels like infallible insight into why things must be so. Why is the square root of 2 irrational? Just follow the steps of the proof and you'll see why it couldn't be otherwise. The downside of the Platonist view is that it does not explain how mathematics can be of any use in the real world of experience, which contains people, physical bodies with imperfect shapes and so on. The view of Plato's student, Aristotle, tries to connect the world of mathematics with the physical world by the process of 'modeling', which admits that things in the real world may have genuinely mathematical properties, like symmetry and divisibility, though perhaps not perfectly.

Let us take one brief example of each kind of mathematics to get a flavour. The most famous unsolved problem in pure mathematics is the Riemann Hypothesis. Its formal statement involves some esoteric concepts, but the main point of it is to give precise information about the distribution of prime numbers. The primes less than 50 are:

$$2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47.$$

Between 980 and 1000, the only primes are 983, 991 and 997. Between 9980 and 10000, there are none. It can be seen that the primes thin out as we go further along the numbers (though they never run out). There is, however, an irregularity or jaggedness to the way they thin out. It is believed, though not proved, that there are an infinite numbers of prime pairs — that is, however far out we go, there is always an occasional pair of odd numbers only two apart that are both primes (like 41 and 43). On the other hand, there are indefinitely long stretches of numbers with no primes at all. Thus the sequence of prime numbers, though it is a matter of absolute necessity and the same in all possible worlds, has the interplay of overall orderliness with local irregularity that we are accustomed to in sequences of throws of dice and coins. In 1859 Riemann conjectured a bold formula that gives information not only about the overall rate at which the primes thin out but about the local irregularities as well. Despite many attacks on it, the problem remains unsolved. It is thought by many experts to be close to being solved, but it is hard to be sure until the story is over.

An example of mathematical modelling is diffusion. If we allow water from a tap to trickle into a bed of sand, initially dry (without forcing it in, just letting the sand soak in what it can), how fast does the wet patch grow? Of course it depends on the type of sand, but can we get a 'big picture' idea of how the distance traveled from source depends on time? Is it linear in time — that is, after twice the time, the water has diffused twice as far from the tap? Or less or more than linear? Most people's intuition suggests less than linear. That is correct. Normal behaviour is that the distance is proportional to the square root of time. A mathematical model of diffusion should explain that. As a first try, one might model the sand by a lattice of points, time by discrete moments, and the diffusion by a chance of a wet point at the edge of the patch wetting the next dry point at the next time interval. One would work with that model by seeing what predictions it makes and then checking if the predictions agreed with observation.

Besides Platonist (pure) and Aristotelian (applied) Mathematics, there is statistics, which now probably provides as many applications and jobs as the rest of mathematics put together. 'Risk' is on many people's minds, and there is plenty of money available to model various kinds of risk. Last year, for example, the (Federal) Department of Agriculture, Fisheries and Forestry funded a new Australian Centre of Excellence for Risk Analysis, to the tune of some $7m. The risks that are the initial focus of its activities are quarantine risks such as those of importing bananas containing pests that could destroy Australian banana crops. But the Centre has a brief to expand by developing mathematically-based methodologies that will be applicable to a wide variety of risks. One particularly difficult problem is to understand how to evaluate extreme risks (for example of catastrophes that have never so far happened). In the nature of the case there is no directly applicable data, so one must combine expert opinion with data on broadly relevant but somewhat different cases that have occurred. Methods for doing that are at present rather primitive and need considerable development.

It is clear that there is no lack of interesting and important problems in mathematics that need urgent attention. There is never enough talent to go around. For a smart person, a degree in mathematics is a path to an astounding range of exciting careers.

Some further reading:

ACERA webpage:

www.acera.unimelb.edu.au/about.html

'A mathematical mind' radio talk:

http://www.abc.net.au/radionational/programs/perspective/james-franklin/3422648

UNSW Quantitative Risk degree:

www.maths.unsw.edu.au/futurestudents/advanced-mathematics-science#QuantitativeRisk

Careers in mathematics:

www.maths.unsw.edu.au/highschool/careers-mathematics-statistics