BOOK REVIEWS

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X and the City: Modeling Aspects of Urban Life by John A. Adam
Princeton University Press, 2012
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X and the City is a spiritual successor to the author's previous work, *A Mathematical Nature Walk* (Princeton University Press, 2011). Whereas that text focussed on mathematical models inspired by the countryside, *X and the City* instead shifts its emphasis to the urban landscape. Over the course of twenty-five chapters (and twelve appendices), Adam uses mathematics to investigate a plethora of city-related phenomena; from the practical (gasoline consumption), to the trivial (counting leaves on trees), to the melodramatic (asteroid impacts).

Each chapter seizes upon a particular theme, the conceit being to redefine the X of the title for each new section. For instance, there are chapters about gardening, air pollution and — perhaps inevitably — sex and the city. In the latter (which actually deals with demographics), X variously represents the current population of the city, the number of bed bugs in the city, and the total number of people to have ever lived in the city.

Some chapters start by developing a basic mathematical formulation and are then content to study variations on, and consequences of, this formulation, thus giving such chapters the shape of an arc from beginning to end. Others are far more varied, and feel more like a manic zigzag from idea to idea. A chapter on life in the city, for example, takes in questions ranging from determining how many doctor's offices are needed in a city, to calculating the optimal viewing angle for a piece of museum statuary, to assessing the likelihood of a long wait in line at the post office. Despite such stylistic differences, however, these chapters can largely be read in any order, and tend to make only fleeting references to one another. The result is that *X and the City* tends to be an easy book to dip in and out of.

That being said, at times Adam does seek to explore topics in greater depth, and consequently some chapters — especially in the second half of the book — are more heavily interrelated. For example, there is a collection of chapters about traffic and vehicular congestion, and another dealing with questions involving problems of optics and light sources. Even in these chapters, however, the text is fairly modular, and consequently instructors should find *X and the City* a great source of ideas to implement in their own lectures or assignments.

The mathematics which Adam brings to bear in *X and the City* is delightfully varied. As might be expected from a text with "modeling" in its subtitle, differential equations play a prominent role. But Adam also incorporates everything from stochastic analysis to simple algebraic exploration. Adam also has a knack for taking familiar problems and considering them from an unusual angle. For instance, Adam gives a typical illustration of the Mean Value Theorem by considering a jogger running at an average speed of 8 miles per hour, and observing that there must therefore be some point in time at which she is running at a speed of exactly 8 miles per hour. But then he observes that this means the jogger covers a mile in an average of 7.5 minutes, and wonders whether this implies that there is a continuous mile that the jogger must run in exactly 7.5 minutes. The resulting mathematics are quite absorbing.

Indeed, it is a hallmark of *X and the City* that Adam writes with an easy, comfortable style. He frequently punctuates potentially dry passages with unexpected humour, and the result is that even models which might, at first blush, hold little appeal for the reader are well worth perusing. Adam does not dwell too long upon the gory details of his mathematics — and the appendices offer some additional background or analysis which would bloat the main text — but he typically has a good sense of how much to retain to preserve readability. There are exceptions to this, such that less mathematically-sophisticated readers may occasionally find themselves struggling to keep up. There is also a not-insignificant number of typographical errors in both text and mathematics that may pose a point of confusion for some. But, by and large, Adam has succeeded in crafting a text which offers something for a very wide audience. Bright high school students through to veteran mathematicians will find much in *X and the City* that is both fascinating and instructive.

Unsolved Crux Problem

Over the years, a number of the proposed problems have gone unsolved. Below is one of these unsolved problems. Note that the solution to part (a) has been published [1996 : 183-184] but (b) remains open.

2025. [1995 : 158; 1996 : 183-184] *Proposed by Federico Ardila, student, MIT, Cambridge, Massachusetts.*

(a) An equilateral triangle ABC is drawn on a sheet of paper. Prove that you can repeatedly fold the paper along the lines containing the sides of the triangle, so that the entire sheet of paper has been folded into a wad with the original triangle as its boundary. More precisely, let f_a be the function from the plane of the sheet of paper to itself defined by

$$f_a(x) = \begin{cases} x \text{ if } x \text{ is on the same side of } BC \text{ as } A, \\ \text{the reflection of } x \text{ about line } BC \text{ otherwise.} \end{cases}$$

(f_a describes the result of folding the paper along line BC), and analogously define f_b and f_c. Prove that there is a finite sequence $f_{i_1}, f_{i_2}, \ldots, f_{i_n}$, with each $f_{i_j} = f_a, f_b$ or f_c, such that $f_{i_n}(\ldots(f_{i_2}(f_{i_1}(x)))\ldots)$ lies in or on the triangle for every point x on the paper.

(b)$\star$ Is the result true for arbitrary triangles ABC?