Chases and Escapes: The Mathematics of Pursuit and Evasion

Paul J. Nahin

PRINCETON UNIVERSITY PRESS 2007, 270 PAGES
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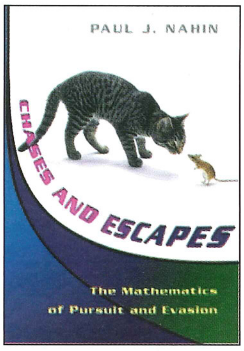
From a very young age we all play "catch me if you can!", Tag being the most well known version, where one person chases others. When the player catches another they say "Tag, caught you, your on". The pursuer then becomes the pursued. The 1968 classic car chase movie Bullitt, had Steve McQueen driving his Mustang GT 390 at speed through the hilly streets of San Francisco. This is a wonderful example of a movie car chase, but I am sure you could name others. These movies show real life cases of pursuit. Another example is a fighter plane in battle following on a pursuit curve to shoot down a bomber aircraft. The fighter will continually point its guns and plane towards the target bomber it is trying to shoot down. As the fighter moves in, closing the gap between itself and its prey, the velocity vector will always be pointing towards the bomber.



In Chases and Escapes, Paul Nahin gives us the first complete history of this fascinating area of mathematics. Writing in an accessible style, he traces the development of modern pursuit theory from its classical analytical beginnings to the present day. His book is full of informed mathematical discussion, fun facts and interesting stories.

The first two chapters in the book deal mainly with problems of pure pursuit. For example here is one of the problems, which is about an invisible evader:

> A coast-guard ship is patrolling the open sea, and spots a smuggler just as thick fog descends and reduces visibility to zero. The coast-guard has a faster ship than the smuggler (and both move at constant speed), but knows that he has been seen and the smuggler will have immediately set off in a random direction to try to slip away through the fog. The coast-guard is some distance from the smuggler when the fog descends, and doesn't even know what direction the smuggler tries to escape in, but he can still steer a course to ensure that he catches the smuggler. What is it?

The third chapter looks in detail at the n-bug problem in which each bug is both a pursuer and a pursued. The final chapter discusses seven evasion problems including Lady in the Lake, Princess and Monster and Rado's Lion and Man. The book chapters have "challenge problems" on the main topics covered, with solutions given in the back.

This informative and entertaining book will appeal to anyone interested in the mathematics of chases and escapes.❑

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Guesstimation

Lawrence Weinstein and John A. Adam

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"**In the movie Spider-Man 2**, Spider-Man stops a runaway New York City six-car subway train by attaching his webs to nearby buildings and pulling really hard for 10 or 20 city blocks. How much force does he have to exert to stop the subway train?"

This is just one of the 76 answered and 33 unanswered questions in the book, Guesstimation, by Weinstein and Adams; the former a professor of physics, the latter a professor of mathematics, both at Old Dominion University. The subtitle of the book is Solving the World's Problems on the Back of a Cocktail Napkin, and is all about making reasonable quantitative estimates of everyday questions. Reasonable means to within an order of magnitude and everyday refers to serious real-world concerns as well as downright silly ones (you can decide for yourself into which category the Spider-Man question falls!). One of the more serious examples is: "How much solar energy reaches the earth in one year?" ($\sim 4\times10^{24}$ J).

Their aim is to help us make sense of the scary numbers thrown at us everyday: "Shark attacks doubled this year!"; "Nuclear power plants produce tons of high-level radioactive waste!"; etc. by using two tools: (1) an understanding of the meaning of large numbers and (2) an ability to make rough, common-sense estimates from just a few basic facts. They do this using plenty of gentle humour and lots of short examples.

They suggest a two step approach. Step 1: estimate the answer. Step 2: If you cannot estimate the answer immediately, break the problem into smaller pieces and estimate the answer for each piece. The nature of the questions is such that exact answers are not what is sought, even if they exist. Estimates to within a factor of ten are what are called for.

Many of their solutions involve estimating upper and lower bounds for various parameters and then taking the approximate geometric mean of the two for use in further calculations which invariably just require simple arithmetic operations.

The approach requires at least a limited knowledge of a number of basic facts and figures. These are supplied in a couple of appendices. One appendix supplies some needed numbers and formulae (e.g. the population of the world; the radius of the earth; the formula for kinetic energy in terms of mass and velocity). The other provides what it calls pegs to hang things on. These are lengths, areas, densities and masses of a range of disparate objects (e.g. the height of Mt. Everest; the area of a football field; the density of a neutron star; the mass of a lethal dose of caffeine).

The book tends to group a family of questions into different chapters: general; animals and people; transportation; energy and work; hydrocarbons and carbohydrates; the earth, moon and lots of gerbils(!); energy and the environment; the atmosphere and risk. It is not a book to read straight through from cover to cover; an approach that could become rather tedious – best to dip in and out, sampling questions from the various chapters as the mood takes you. It is small and fits easily into a brief-case or (large) pocket, making it ideal to while away the delays caused by the signalling problems at Milton Keynes, or the accident just ahead of you on the M6!