odds-inversion.nb Table of Contents

Beyond *Varsity Math:*The red-and-blue-balls puzzle
An odds inversion problem

1 Introduction

- 1.1 Acknowledgements and references
- 1.2 To the reader
- 2 The Varsity Math problem
- 3 Generalizing the problem
- 3.1 Questions to be answered
- 3.2 Main results
- 4 Preliminaries
- 4.1 Notation
- 4.2 Setting up the problem
 - 4.2.1 The Diophantine equation
 - 4.2.2 Formal and admissible solutions
 - 4.2.3 Trivial solutions
 - 4.2.4 Symmetry
 - 4.2.5 Change of variables
 - 4.2.6 Existence and completeness of solutions
 - 4.2.7 Mathematica

5 Exploring the problem

- 5.1 The character of the equation
 - 5.1.1 Plotting the equations

What values of *D* are possible?

5.2 Trivial solutions

5.2.1 Additional solutions that always exist if q = 2p - 1

5.3 Reverse search

5.3.1 Selected results of reverse search

5.4 The "recycling" recurrence

- 5.4.1 Examples
- 5.4.2 Elliptical case
- 5.4.3 When removing one ball does not change the odds
- 5.4.4 Function to generate recycling series

6 Special cases

- 6.1 Special case: p/q == 0
- 6.2 Special case: p/q == 1
- 6.3 Special case: p == 1 or 2

7 Parabolic case: p/q == 1/2

8 Elliptical case: p/q > 1/2

8.1 Method of bracketed direct search

8.1.1 Plotting the elliptical case vs. z

8.2 Function to solve elliptic case by bracketed search

	Examples
8.2.2	Example of a very elongated ellipse
8.3 Exl	naustive enumeration of solutions
8.3.1	Refining the bound
8.3.2	Enumeration of elliptical solutions with x , $y < 999$
8.4 Pla	cing bounds on <i>p</i> and <i>q</i>
8.5 Ve	tex solutions
8.5.1	Symmetry when vertex solutions exist
8.5.2	Midsection solutions
8.5.3	Near-triangular solutions
9 Нур	perbolic case: p/q < 1/2
9.1 Sig	n of <i>u</i> , <i>v</i> and admissibility of solutions
9.2 Gr	owth rate of solutions for small <i>p q</i>
10 Hy	perbolic case, <i>D</i> > 0 square
10.1 R	atios <i>p q</i> giving <i>D</i> square
10.2 M	ethod of factorization
10.3 Ex	xistence and completeness of solutions
10.4 B	ound on magnitude of solutions
10.5 F	unction to solve hyperbolic square <i>D</i> case

10.5.1 Examples: ratios with smallest p, q giving square D

Example with larger q, p/q close to 1/2

11 Hyperbolic case, D > 0 nonsquare

11.12 Method of solution by reduction of RHS to 1

11.1 Continued fractions
11.2 Convergents
11.3 Conversion to Pell equation
11.4 Solution of Pell equation
11.4.1 Example: $p/q == 7/18$
11.5 Functions to solve the Pell equation
11.6 A cautionary example: $p/q == 6/17$
11.7 Function to solve hyperbolic case via Pell Equation
11.8 Solutions from the trivial solutions via Pell recurrence
11.9 Classes of solutions
11.9.1 Solution classes and fundamental solutions
11.9.2 Completeness
11.9.3 Functions for testing if two solutions are in the same class
11.10 Solving hyperbolic case by direct search
11.10.1 Bounds on size of fundamental solution
11.10.2 Function to find fundamental solutions (u, v) by direct search
11.10.3 Function to solve hyperbolic case for (x, y) by search
11.11 Feasibility of search

12.4 Recycling recurrence is complete for p == 1 and p == 2

13 Solving using Mathematica

14 Open questions

14.1 Special cases

14.2 Properties of the recycling recurrence