

S -Motzkin paths with catastrophes and air pockets (very early version)

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Abstract

So called S -Motzkin paths are combined the concepts ‘catastrophes’ and ‘air pockets’. The enumeration is done by properly set up bivariate generating functions which can be extended using the kernel method.

Keywords: S -Motzkin path; catastrophe; kernel method; air pocket.

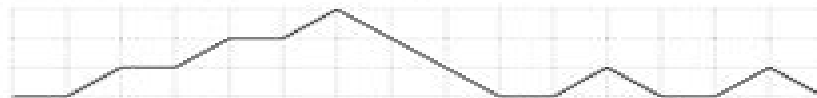
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1. Introduction

Dyck paths consist of up-steps $(1, 1)$ and down-steps $(1, -1)$, start at the origin and do not go below the x -axis; they appear in many texts, we just give one major reference, [12]. Typically, the path returns to the x -axis at the end, but we also consider the scenario of open paths, where the paths end at level j , say. A popular variation of Dyck paths are Motzkin paths: the difference is just that now a horizontal step $(1, 0)$ is also allowed.

In this paper, we concentrate on S -Motzkin paths, which is a subfamily of all Motzkin paths: all three steps (up, level, down) must appear n times, and, ignoring the down-steps, the sequence is $(1, 0)(1, 1)(1, 0)(1, 1)(1, 0)(1, 1) \dots (1, 0)(1, 1)$. The follow figure shows how these paths are recognized: The two layers enforce that the flat and up steps are interlaced. Only paths that end in the origin are S -Motzkin but we consider all paths wherever they end.

Here is an example of such an S -Motzkin path with 15 steps:



Now we present a graph (automaton) to recognize exactly the S -Motzkin paths:



Figure 1: Graph to recognize S -Motzkin paths; they start and end at the special state (origin).

This subfamily of Motzkin paths originated from a question in a student competition; see [10] and [7] for history and analysis. In the following we will combine this family with catastrophes and air pockets, both originating in papers by Jean-Luc Baril and his team [5], [3]; the older paper by Banderier and Wallner [2] might be called the standard reference for lattice paths with catastrophes. The very recent papers [4,5] contain some bijective aspects. Our own paper [9] investigates the situation in the context of skew Dyck paths.

Dyck (and other lattice) paths with catastrophes are characterized by additional steps (‘catastrophes’) that bring the path back to the x -axis in just one step from any level $j \geq 2$. For S -Motzkin paths the definition is similar, and the graphical description in Figure 2 is easiest to understand; the catastrophes are drawn in special colors.

In the last section, S -Motzkin paths with air pockets will be discussed. Briefly, down steps of any length are now allowed, but no two down steps may follow each other.

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Table of Contents Selected Papers Of Theodore S Motzkin

1. Understanding the eBook Selected Papers Of Theodore S Motzkin
 - The Rise of Digital Reading Selected Papers Of Theodore S Motzkin
 - Advantages of eBooks Over Traditional Books
2. Identifying Selected Papers Of Theodore S Motzkin
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Selected Papers Of Theodore S Motzkin
 - User-Friendly Interface
4. Exploring eBook Recommendations from Selected Papers Of Theodore S Motzkin
 - Personalized Recommendations
 - Selected Papers Of Theodore S Motzkin User Reviews and Ratings
 - Selected Papers Of Theodore S Motzkin and Bestseller Lists
5. Accessing Selected Papers Of Theodore S Motzkin Free and Paid eBooks
 - Selected Papers Of Theodore S Motzkin Public Domain eBooks
 - Selected Papers Of Theodore S Motzkin eBook Subscription Services
 - Selected Papers Of Theodore S Motzkin Budget-Friendly Options
6. Navigating Selected Papers Of Theodore S Motzkin eBook Formats
 - ePub, PDF, MOBI, and More
 - Selected Papers Of Theodore S Motzkin Compatibility with Devices
 - Selected Papers Of Theodore S Motzkin Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Selected Papers Of Theodore S Motzkin
 - Highlighting and Note-Taking Selected Papers Of Theodore S Motzkin
 - Interactive Elements Selected Papers Of Theodore S Motzkin
8. Staying Engaged with Selected Papers Of Theodore S Motzkin

- Joining Online Reading Communities
- Participating in Virtual Book Clubs
- Following Authors and Publishers Selected Papers Of Theodore S Motzkin
- 9. Balancing eBooks and Physical Books Selected Papers Of Theodore S Motzkin
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Selected Papers Of Theodore S Motzkin
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Selected Papers Of Theodore S Motzkin
 - Setting Reading Goals Selected Papers Of Theodore S Motzkin
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Selected Papers Of Theodore S Motzkin
 - Fact-Checking eBook Content of Selected Papers Of Theodore S Motzkin
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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