Chapter 10
Random Combinations

ABSTRACT

The chapter analyses the Random combinations. Random combinations in mathematics offer a creative approach by using probabilistic methods to generate new selections of elements from a given set. Unlike classical combinations, which follow strict rules and produce all possible selections, random combinations use probabilistic techniques to create subsets randomly. Applications of random combinations include statistical sampling, marketing tests, games of chance, and financial analysis. These methods can stimulate creativity and innovation in fields such as creative painting, music, storytelling games, and brainstorming. For example, an artist might randomly mix colors and geometric shapes to create new compositions, or a musician might generate new melodies by randomly combining instruments. Additionally, random combinations are used in scientific contexts, such as generating random graphs, simulating complex events, and optimizing hyperparameters in machine learning.

INTRODUCTION

Nothing happens by chance, but everything according to reason and necessity

Leucippus

When we think of mathematics, we often imagine strict rules and precise calculations. However, there is a more creative side: random combinations allow us to mix elements to open up to new discoveries. Sometimes, the most unexpected paths lead to the most interesting discoveries. Random combinations, therefore, are a way to get off the beaten track and let us be guided by the unexpected.

In combinatorics, random combinations are an unstructured approach to generating new selections of elements from a given set or multiple sets (Deng, 2022). Unlike classical combinations, which follow stringent mathematical rules and produce all possible selections, random combinations use probabilistic methods to create subsets randomly.

Table 1. Differences between combinations

Characteristic	Classic Combinations	Random Combinations
Selection Method	Systematic and mathematical	Random and probabilistic
Rules	Follows fixed rules	Case-based
Reproducibility	Identical results with the same parameters	Variable results even with the same parameters
Example of Use	Calculation of possibilities	Statistical sampling

Classic Combinations follow fixed rules, often defined by deterministic algorithms, ensuring the reproducibility of the results. Random Combinations are ideal in statistical or simulation contexts, such as random sampling for data analysis or experiments. Random combinations offer flexibility and adaptability, making them particularly useful in

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various fields, including statistics, creativity, computer security, and complex simulations. These advantages make them preferable to classical combinations where unpredictability and variability are required.

Random combinations represent a significant frontier in combinatorics. Before examining some particular cases, it may be significant to report some concrete examples:

- *Statistical sampling*: A researcher must select a random sample of n people from a population of n individuals. In this case, a random number generator draws individuals randomly, ensuring that each member of the population has an equal chance of being chosen.
- *Testing in marketing*: A company wants to test two versions of an advertisement (A and B) on a random sample of users. Users are randomly assigned to one of two groups (A or B). This prevents results from being influenced by external factors, ensuring an equal distribution among groups.
- *Games of chance*: One could take a set of numbers and generate random combinations. This method is used in the Italian Superenalotto or the English National Lottery to propose six random numbers.
- *Financial analysis*: An analyst can use random simulations to generate thousands of scenarios, utilising probabilistic distributions for the economic variables that affect the markets.

A particularly interesting example is the following: one could combine a set of words and images to generate new stories or poems. This process can be likened to using a "mental blender" to discover new combinations of available elements. One starts with a list (concepts, objects, ideas) and proceeds with a selection without being bound to a specific order. Next, a random shuffle of the selected elements is conducted. This process can lead to new associations, inspirations, or creative solutions.

List items such as words, colours, images, or concepts and then randomly select a couple to explore new associations or ideas. This process of random selection and mixing can stimulate creativity and innovation.

Some examples can be given to help understand this approach.

- *Brainstorming*: This creative group thinking technique generates new and innovative ideas in many situations. Example: In an advertising company, a team wants to generate new ideas for a product. A list of attributes could include the words "Sustainability", "Innovation", "Ecology", "Future", "Efficiency", and "Digital". A random combination could lead to three elements, such as "Ecology", "Innovation", and "Sustainability", which would lead to a campaign that highlights an environmentally friendly product that can contribute to a more sustainable future through innovation.
- *Creative painting*: An artist takes a series of colours and geometric shapes, randomly mixes them, and arranges them on a canvas to see what composition emerges. Example: Having "Yellow," "Red," "Blue," "Circle," "Square," or "Triangle" available, you could obtain, by selecting two elements, a blue square, a red triangle, or a completely green square (blue + yellow).
- *Creative music*: Random combinatorics can generate new melodies, chords, and arrangements. Example: Consider a set of instruments such as "Piano", "Guitar," "Saxophone", and "Drums." We can use random combinatorics to generate an arrangement by randomly combining three instruments from this set. For example, we can generate a new arrangement with (Saxophone, Piano, Guitar) or (Guitar, Saxophone, Drums).
- *Creative play*: There are creative storytelling games on the market in which players roll nine special dice with images and then have to create a story based on the visuals displayed using all or even just a part of the dice. Example: Once the dice have been rolled, each player will be the Storyteller, who must create a story starting with the classic "Once upon a time..."
- *Creative writing*: An author wants to draft an original story. He writes a list of keywords, then randomly selects two or more items from the list and tries to develop a story based on those combinations. Example: starting from five words such as "Moon", "Solitude", "Adventure", "Forest", and "Storm", one can extract all combinations of two words. Supposing to extract "Luna" and "Storm", one could create a story in which a traveller, under the rays of the moon, finds himself hit by a terrible storm. With the words "Solitude" and "Adventure", the story could be of a traveller who, walking under the weight of solitude, suddenly found himself involved in a magical adventure.