Notes on
A Mathematics Course for Political and Social Research

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1 Citation

This is a note for
A Mathematics Course for Political and Social Research by Will H.Moore and
David A.Siegel.

2 Keywords

Calculus; Probability; Linear Algebra

3 Commentary

- This note is created by Enbang Wu at the University of Wisconsin-madison for the UWM political science graduate math camp 22-23.

- This note is mainly to clarify some important concepts and make it easier for readers.

- The range of this note is from Chapter 1 through Chapter 13. And not all of the chapters are covered, but you can contribute to the missing part.

- This note is an open source project under the MIT license and welcome any contribution!

4 Contribution

Contribute to this note by making pull requests on this Github repo

Contents

5 Preliminaries Math, Chap 1-4

In this chapter, it introduces some of the most fundamental math concepts. To better understand them, we will provide some metaphors.

5.1 Sets:

- Countable sets: A countable set compromises discrete elements. You can think of it like there is a hole or distance among the elements, no matter how close they are.

- Uncountable sets: A uncountable set compromises continues elements. In mathematical language, no matter how small a distance is given, I can always find elements that fit in.

Countable sets and uncountable sets are important because you will find that they share a similar idea with calculus and calculus-based probability.

5.2 Difference between functions and equations

Functions and equations are both widely used in our life but they are different. A function is a **relation** that associate the input to the output. A equation is a **statement** that two expressions are equal.An function can often be written as equation, but not every equation is a function.

5.3 Nonlinear Functions: Exponents, Logarithms, and Radicals

In this part, you should take extra attentions to the rules of nonlinear functions because they are different than what you have learner before.
For exponents:

- Multiplication: $x^m \times x^n = x^{m+n}$

- Division: $x^m \div x^n = x^{m-n}$

For logarithms: Logarithms can be thought as the inverse of exponents. The logarithm of x^m is $m \log(x)$.
For radicals: Roots are those are those numbers represented by the radical symbol.

- $x^m \sqrt{x^n} = x^{m/n}$

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6 Calculus: Differentiation, integration, and optimization, Chap 5-8

Upon learning the new concepts of calculus, I found that some visualization would be very helpful. So here are some websites or YouTubers that I think will help you learn the concepts.

- Quick calculus concepts

- Deeper and longer calc videos explained 3blue1brown

with that been said, let's continue to declare the concepts.

6.1 Derivative

In a word, derivative is the instantaneous rate of change of a function. In life, we may wanna know how far you can make by walking in 15 minutes, and that's the derivation of distance with respect to time. But time is just one example, we can also ask for the derivation with respect to space, population or anything. And that's the essence of the derivation.

6.2 Integral

If the derivative is about the instantaneous rate of change then anti-derivative or the integral is about the sum. The definite integral is a value whereas the indefinite integral is the function. And that's the fundamental truth behind the calculus: change and sum.

7 Probability, Chap 9-11

7.1 Classic probability

Probability is the formal language to understand how likely a thing would happen in the some circumstances. When learning probability, I found Khan Academy is helpful to understand the concepts: Khan probability
To start with a simple case, the probability of flipping a coin with its head on is 1/2. And flipping a coin twice with 2 heads is a joint probability, and flipping a coin with different shape (assume that will affect the outcome) is called conditional probability.

7.2 Discrete distribution

OK then, you may ask, what if we want to compare the probability of flipping a coin with different shapes or weights? Then we may use a frequency distribution to record how many times heads on for a fixed number of flips with different coins. And that's where the generalization comes.
In a more complicated case, where we have more then just 2 choices, we may

wonder what's the probability of drawing one choice from the sample spaces.
Then we need **Probability Mass Function,(PMF)** it tells us the probability of drawing a specific discrete value from the sample space. You can also think this as a measure of different weights of choices, that's where the mass comes from.
If the variables are not discrete but continuous, then we need the **Probability Density Function, (PDF)**
And if we are not asking for a probability with respect to a specific variable but a range that covers some of them, then we call it **Cumulative Distribution Function, (CDF)** and is defined for both discrete and continuous functions.

8 Linear Algebra, Chap 12-13

Upon learning linear algebra, I think this intuitive guide will lead you the way:
linear algebra guide
Linear Algebra provides us with a new way to solve the equations and the insight to study multidimentions.