A Guide to Mathematics for Undergraduate Economics Students

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Preamble

On the occasion of my graduation, as I was sorting through my books, I came across many textbooks on mathematical economics that I had read. To be honest, my training in mathematics courses during undergraduate was not solid enough, so I needed to read a great deal of supplementary materials. Based on my experience of having read more or less through them, I have put together this guide.

As the mathematical requirements of economics PhD programs have risen steadily over the past decades, I am well aware that many undergraduates like me may need corresponding learning and training in mathematical skills. This guide addresses two distinct groups of readers.

1 Track A: Students with Abundant Mathematical Resources

If you hold an undergraduate degree in mathematics, or if your university offers excellent courses from Department of Mathematics, then the most direct and most rewarding path is to take (or audit) the following core courses:

- **Real Analysis** – the foundation for optimisation theory, fixed-point theorems, measure theory, and functional analysis used in general equilibrium and game theory.
- **Functional Analysis** – essential for infinite-dimensional optimisation, spaces of functions, and duality in economic theory.
- **Dynamic Optimization** – including calculus of variations and optimal control, central to macroeconomics, resource economics, and growth theory.
- **Stochastic Processes** – indispensable for financial economics, and econometric theory.
- **Ordinary Differential Equations** – the basic language of dynamic systems.

Congratulations! If you can access to these resources at your institution, then they will be more than sufficient to equip you with the mathematical knowledge required for graduate studies in economics. The only additional thing you need is training in applying that knowledge to economic contexts. If you have already covered them, you will find the PhD core courses (and the Math Camp) quite manageable.

2 Track B: Students with Only the "Three-Piece Set"

However, most economics undergraduates only receive training in calculus, linear algebra, and probability/statistics or are lack of math course resources from their university. For such students, jumping directly into real analysis or functional analysis is usually too ambitious. A sound remedy is a systematic self-study through a dedicated Math Camp or self-guided reading.

The following classic textbooks are widely used in bridging the gap. **It is strongly recommended to work with the English originals** from the outset, to align with international terminology and research literature, though all of them have Chinese translations.

Introductory – The Most Accessible Starting Point

1. ***Mathematics for Economics*** (4th edition)
   Michael Hoy, John Livernois, Chris McKenna, Ray Rees, & Thanasis Stengos
   Original English edition: MIT Press, 2022 (ISBN: 9780262046626).
   This is the most accessible entry point. The only prerequisite is high school algebra, yet the book covers all the mathematics needed for undergraduate economics across five parts: fundamentals, calculus, linear algebra, optimisation, and dynamics. It contains numerous worked examples drawn from economic theory, environmental economics, financial economics, public economics, and industrial organization. The fourth edition adds "Reader Assignments" to test understanding as you go. A student solutions manual is available for odd-numbered exercises.

Introductory to Intermediate – Building the Foundation

2. ***Fundamental Methods of Mathematical Economics*** (4th edition)
   Alpha C. Chiang & Kevin Wainwright
   Original English edition: McGraw-Hill, 2005.
   This is the most classic introductory text. Many master or phd program's *MATH Camp* choose it as the reference. It covers static optimisation, comparative statics, linear algebra, differential equations, and includes a modern treatment of the envelope theorem, optimisation frontiers, and an introduction to optimal control.

Intermediate – The Optimisation Classic

3. ***Optimization in Economic Theory*** (2nd edition)
   Avinash K. Dixit
   Original English edition: Oxford University Press, 1990/1991 (ISBN: 9780198772101).
   This is a masterpiece of clarity and concision. At only 188 pages, it covers the core of static and dynamic optimisation methods: Lagrange's method, extensions and generalisations, shadow prices, maximum value functions, convex sets and separation, concave programming, second-order conditions, the maximum principle (continuous time), dynamic programming (discrete time), uncertainty, and the Kuhn-Tucker theorem. Building on simple economic theory and elementary linear algebra and calculus, it reinforces every mathematical idea with its economic application. It is the perfect bridge between Chiang's introductory treatment and the more advanced Silberberg & Suen or Simon & Blume.

Intermediate – The Core of Static Economic Analysis

4. ***The Structure of Economics: A Mathematical Analysis*** (3rd edition)
   Eugene Silberberg & Wing Suen
   Original English edition: McGraw-Hill/Irwin, 2000 (ISBN 0-07-118136-9).
   This book is the definitive treatment of the *comparative statics* of neoclassical economics, using rigorous calculus and linear algebra. It systematically develops the theory of cost and production, consumer demand, and general equilibrium through the lens of duality (Shephard's lemma, Roy's identity, etc.). The mathematical level is higher than Chiang's and is particularly suited for students who want to master microeconomic theory at the advanced undergraduate / early graduate level.

Intermediate to Advanced – Broad Mathematical Coverage

5. ***Mathematics for Economists***
   Carl P. Simon & Lawrence Blume
   Original English edition: New York: Norton, 1994.
   Written for advanced undergraduates and first-year graduate students, this book covers linear algebra, multivariate calculus, optimisation, and dynamical systems, with abundant economic applications and exercises. It is broader than Silberberg & Suen (covering dynamics and linear algebra in more detail) and serves as an excellent comprehensive reference.

Dynamic Optimization – The Macroeconomics Companion

6. ***Elements of Dynamic Optimization***
   Alpha C. Chiang
   Original English edition: Waveland Press, 1999.
   A natural continuation of Chiang's fundamental book, this volume systematically introduces calculus of variations and optimal control, including Euler equations, transversality conditions, and the maximum principle—essential for modern macro and growth theory.

3 Study Advice

1. **Proceed step by step.** Start with Hoy et al. to build a solid foundation. Then move to Chiang's *Fundamental Methods* to deepen your understanding. Next, read Dixit's *Optimization in Economic Theory*——it is short, clear, and will solidify your grasp of optimisation like nothing else. Then tackle Silberberg & Suen for a proof-oriented treatment of static theory. Supplement with Simon & Blume for missing topics, and finally study Chiang's *Elements of Dynamic Optimization* for macro applications. Furthermore, for PhD-level macroeconomics, Sargent's Dynamic Programming is an advanced manual while it goes beyond the scope of undergraduate studies.

2. **Do all exercises.** Mathematical economics is learned by doing, not by reading alone.

3. **Connect with economic intuition.** For every mathematical concept, ask: where does this appear in economic theory? (consumer/producer theory, growth models, general equilibrium, etc.)

4. **Read the English originals as early as possible.** The frontier literature is overwhelmingly in English. Familiarity with mathematical English is an essential research skill.

Final Remarks

There is no shortcut to mathematical training. I often believe that *learning mathematics is a lifelong process*. If you come from a university with a strong mathematics department, take their advanced analysis courses. If not, the classic textbook path above is a reliable and time-tested bridge. In either case, persistent practice and a clear grasp of economic intuition are equally important.

"Mathematics is the language in which God has written the universe." —— Galileo