THE UNIVERSITY of WISCONSIN MADISON

Math Requirements for Incoming and Post-First-Year Graduate Students

This document describes the Department's expectations about students' mathematical knowledge at two points in their course of study: upon entering the program, and before taking the preliminary exams at the end of the first year.

I. Incoming graduate students

The department requires incoming students to have completed the following courses before starting graduate study:

- A three-course sequence in calculus, including multivariate calculus
- One course in linear algebra
- One course in mathematical statistics

While most of the material in these classes is useful for graduate work in economics, it is not always clear to incoming students which topics covered in these classes are most important to review before graduate coursework begins. We list five key topics below. Two useful references on these topics are

[DS] M. H. DeGroot and M. J. Schervish, *Probability and Statistics*. 3rd ed. Boston: Addison-Wesley, 2002.

[SB] C. P. Simon and L. E. Blume, *Mathematics for Economists*. New York: Norton, 1994.

The first item summarizes the contents of a standard mathematical statistics class:

1. Basic probability theory (discrete and continuous random variables, conditional probability, expectations, the weak law of large numbers, the Central Limit Theorem) and basic mathematical statistics (point estimation, interval estimation, hypothesis testing). [DS, various chapters].

The next three should be familiar from the calculus course sequence:

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2. Geometric representation of vectors and functions in *n*-dimensional space [SB, Ch. 10 and Sec. 13.2].

3. Differentiation of multivariate functions [SB, Sec. 14.1-14.6].

4. Unconstrained optimization, and equality constrained optimization via the Lagrange multiplier method [SB, Ch. 17 and Sec. 18.2].

The last item is not covered in all undergraduate calculus sequences. Still, we advise students to study this topic before classes begin.

5. Basic convexity [SB, Sec. 21.1-21.3].

II. Students completing first-year coursework

By the time first-year course work is over, students have learned a wide range of mathematical techniques for economic analysis. Below, we list some fundamental topics that students should master before taking the micro and macro prelims. As additional references, we mention two standard textbooks for the macro curriculum and one for the micro curriculum:

[S] T. J. Sargent, *Macroeconomic Theory*. 2nd ed. San Diego: Academic Press, 1987.

[SL] N. L. Stokey and R. E. Lucas, *Recursive Methods in Economic Dynamics*. Cambridge: Harvard University Press, 1989.

[MWG] A. Mas-Colell, M. D. Whinston, and J. R. Green, *Microeconomic Theory*. New York: Oxford University Press, 1995.

N.B.: The Department does not merely expect students to be able to recite the basic results from each of the areas listed below. Rather, we expect students to possess a *working knowledge* of each topic on the list. This means, for example, that students should be able to recognize situations in which the various techniques are relevant, and should understand how to put the techniques to use.

Two broad, fundamental topics from the first year theory sequences are:

1. Constrained optimization, the Kuhn-Tucker conditions, and concave maximization [SB, Ch. 18, 19, 21, and 22; MWG, Sec. M.K].

2. Comparative statics, implicit differentiation, and the implicit function theorem [SB, Ch. 15 and 22; MWG, Sec. M.E and M.K].

Two topics that are especially important for the macro sequence are:

3. Mathematics for time series analysis: difference equations, linear regression, Wold representation for time series, spectral analysis [S, Ch. 9-11].

4. Dynamic programming [SL, various chapters].

Two narrowly defined topics closely related to items 1 and 2 are:

5. Homogeneous functions [SB, Sec. 20.1; MWG, Sec. M.B].

6. The Envelope Theorem [SB, Sec. 19.2; MWG, Sec. M.L].

Finally, four important "theoretical" topics are:

7. Compactness and the Weierstrass Maximum Theorem [MWG, Sec. M.F].

8. The Theorem of the Maximum [MWG, Sec. M.K].

9. Basic fixed point theory, especially Brouwer's Theorem [MWG, Sec. M.I].

10. The Separating Hyperplane Theorem [MWG, Sec M.G].