

**Mathematical Methods for Agricultural and Resource Economists
Syllabus**

SB refers to Mathematics for Economists, by Carl Simon and Larry Blume (SB). MWG refers to Mathematical Appendix to Microeconomic Theory, by Mas-Colell, Whinston and Green (MWG). The texts are only peripherally related to the course material. The chapter guides are approximate.

- (1) **Analysis** SB(12,29,A1), MWG(M.F)
 - (a) Sequences
 - (b) Distance/Metrics
 - (c) Convergence of Sequences
 - (d) Geometric series
 - (e) Least Upper bounds and Greatest Lower Bounds
 - (f) Cauchy Sequences
 - (g) Topology of \mathbb{R}^n
 - (h) Continuous Functions
 - (i) Upper and Lower Hemi-continuous correspondences

- (2) **Graphical Overview of Calculus & Optimization Theory** (no text).
 - (a) Necessary and Sufficient Conditions
 - (b) Unconstrained optimization — one variable
 - (c) Convex sets, Concave and Convex Functions
 - (d) Separating Hyperplanes
 - (e) Strictly Concave and Convex Functions and Strict (Locally Unique) Maxima
 - (f) Constrained optimization — one variable
 - (g) Unconstrained optimization — several variables
 - (h) Taylor's theorem, "orders of small"
 - (i) Level Sets, upper and lower contour sets and gradient vectors
 - (j) Quasiconcavity and quasiconvexity; strict quasiconcavity
 - (k) Constrained optimization — several variables
 - (l) Envelope theorem and Implicit function theorem

- (3) **Linear Algebra** SB(6-11,16,23,26,27), MWG(M.D)
 - (a) Vectors as arrows.
 - (b) Vector operations
 - (c) Projections
 - (d) Proof of the cosine formula theorem
 - (e) Linear Combinations, Linear Independence, Linear Dependence and Cones.
 - (f) Vector Spaces
 - (g) Spanning, Dimension, Basis
 - (h) Matrices and Rank
 - (i) Matrix notation vs summation notation
 - (j) Linear Functions
 - (k) The "graph" of a linear function from \mathbb{R}^2 to \mathbb{R}^2
 - (l) Computational details
 - (m) Derivatives of matrices
 - (n) Determinants, Rank and volume
 - (o) The right hand rule
 - (p) Solving linear equation systems and Cramer's Rule
 - (q) Eigenvalues, eigenvectors and difference Equations

- (4) **Univariate and Multivariate Differentiation** SB(2-4,14,30)
- (a) The fundamental notion: linear approximations to nonlinear functions.
 - (b) The Differential in Univariate Calculus
 - (c) Partial Derivative, Cross Partial and Total Derivatives
 - (d) The differential in Multivariate Calculus: real-valued functions
 - (e) The differential in Multivariate Calculus: vector-valued functions
 - (f) Support functions and separating hyperplanes
 - (g) Taylor's Theorem
 - (h) Application of Taylor's theorem: 2nd order conditions for an unconstrained maximum
 - (i) Integration: Leibnitz's rule
- (5) **Characteristics of functions** SB(13.5, 20, 21), MWG(M.C)
- (a) Terminology Review
 - (b) Surjective, Injective and Bijective functions
 - (c) Homotheticity
 - (d) Homogeneity and Euler's theorem
 - (e) Monotonic functions
 - (f) Concave and quasi-concave functions; Definiteness, Hessians
 - (g) Second Order conditions, Definiteness and Semidefiniteness
 - (h) Hessian sufficient conditions for quasi-concavity and concavity
- (6) **Constrained Optimization** SB(18,19), MWG(M.K)
- (a) Existence and Uniqueness
 - (b) Necessary and sufficient conditions for a solution to an NPP
 - (c) Demonstration of why the KT conditions are really necessary
 - (d) Interpretation of the Lagrange Multiplier
 - (e) KT conditions and the Lagrangian approach
 - (f) Computing a solution to a NPP: a worked example
 - (g) Second Order conditions for a Constrained Maximum
 - (h) The Hamiltonian
- (7) **Foundations of Comparative Statics** SB(15,19.2), MWG(M.E, M.L)
- (a) The envelope theorem (unconstrained version).
 - (b) The envelope theorem (constrained version).
 - (c) Implicit function theorem
 - (d) Genericity and Transversality
 - (e) The implicit function theorem and comparative statics.
 - (f) The inverse function theorem