

# MAE 674 Optimal Estimation Methods

**Instructor:** Dr. John L. Crassidis  
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**Textbook:** **Optimal Estimation of Dynamic Systems** (2<sup>nd</sup> Edition) by John L. Crassidis and John L. Junkins. CRC Press, Boca Raton, FL, 2012.

**References:** **Optimal Control and Estimation** by R.F. Stengle. Dover Publications Inc., 1994  
**Introduction to Random Signals and Applied Kalman Filtering** (3<sup>rd</sup> Edition) by R.G. Brown and P.Y.C. Hwang, John Wiley & Sons, 1997

**Prerequisites:** Matrix Theory (or equivalent) and Statistical Methods (or equivalent)

**Objective:** To learn about traditional concepts and recent advances in estimation, and to relate these concepts to modern dynamic systems found in aerospace and mechanical disciplines. This course stresses modeling of physical problems into mathematical terms.

**Outline:** Class 1: Introduction and Matrix Algebra Review (Appendix B)  
Class 2: Parameter Optimization Review (Appendix D)  
Class 3: Least Squares Estimation (§1.1–§1.2)  
Class 4: Sequential Estimation and Nonlinear Least Squares (§1.3–§1.4)  
Class 5: Basis Functions and Advanced Least Squares Topics (§1.5–§1.6)  
Class 6: Basic Probability Concepts (Appendix C)  
Class 7: Minimum Variance Estimation & Cramér-Rao Inequality (§2.1–§2.3)  
Class 8: Maximum Likelihood & Maximum A Posteriori Estimation (§2.6–§2.7)  
Class 9: Review of Homework 1  
Class 10: Total Least Squares (§2.8.4)  
Class 11: Review of Dynamic Systems: Part I (Appendix A)  
Class 12: Review of Dynamic Systems: Part II (Appendix A)  
Class 13: Review of Homework 2  
Class 14: Review Material for Test 1  
Class 15: Test 1  
Class 16: Kalman Filtering: Part I (§3.1–§3.3)  
Class 17: Kalman Filtering: Part II (§3.3)  
Class 18: Kalman Filtering: Part III (§3.4–§3.5)  
Class 19: Unscented Kalman Filtering (§C.5, §3.7)  
Class 20: Batch State Estimation: Part I (§5.1.1)  
Class 21: Project Proposal Outline, Batch State Estimation: Part II (§5.1.1–§5.1.3)  
Class 22: Particle Filtering: Part I (§4.10.1–§4.10.2)  
Class 23: Particle Filtering: Part II (§4.10.2–§4.10.3)  
Class 24: Advanced Topics (§4.6.2, §4.5, §4.7)  
Class 25: Target Tracking & Orbit Determination (§7.4.1–§7.4.2, §6.4, §7.3)  
Class 26: Review of Homework 3  
Class 27: Review Material for Test 2  
Class 28: Test 2

**Grading:** Projects 50%, Tests 50% (25% each)

No make-up exams or incomplete grade will be given without a University excused absence.

**Academic Integrity:** Read <https://catalog.buffalo.edu/policies/integrity.html>. Students are expected to follow the UB guidelines on academic integrity. This will be taken very seriously in this course.