

AERSP 566 Applied Optimal Estimation Spring 2024

- Instructor: Prof. Eric N. Johnson
Room 229C Hammond Building
E-mail: eric.johnson@psu.edu
Office hours: TTh, 1:30-2:30pm, or by appointment
(Appointment recommended: eric.johnson@psu.edu)
- Class: Engineering Unit B, room 107
TTh, 12:05-1:20pm
- Topics:
1. Random variables and stochastic processes
Probability, probability distributions, correlation/covariance, ergodicity, white vs. colored noise, shaping filter, air turbulence model example
 2. Kalman filter
Least squares estimation, discrete Kalman filter, continuous Kalman filter, divergence issues, colored measurement noise, sequential Kalman filter, information filter, verifying performance, state constrained filtering
 3. Kalman filter for nonlinear systems
Linearized Kalman filter, Extended Kalman Filter (EKF), parameter estimation, hybrid continuous-discrete filter, alternate formulations, detailed aerospace navigation and tracking examples
 4. Unscented Kalman Filter (UKF) and Particle Filter (PF)
UKF, unscented transforms, Bayesian state estimation, PF, resampling, implementation issues, examples
- Grading: Homework 50%, Midterm 15% (date TBD), and Final 35% (date TBD)

Selected References:

1. (class text) Simon, *Optimal State Estimation*, Wiley, 2006.
2. Gelb, *Applied Optimal State Estimation*, MIT Press, 1974.
3. Brown and Hwang, *Introduction to Random Signals and Applied Kalman Filtering*, 4th Edition, Wiley, 2012.
4. Bierman, *Factorization Method for Discrete Sequential Estimation*, Dover, 1977.
5. Bar-Shalom, Li, and Kirubarajan, *Estimation with Applications to Tracking and Navigation*, Wiley, 2001.
6. Zarchan and Musoff, *Fundamentals of Kalman Filtering: A Practical Approach*, 3rd Edition, AIAA, 2009.
7. Stengel, *Optimal Control and State Estimation*, Dover, 1986/1994.

Policies: Homework is due at the *beginning* of class on the day it is due. Late homework will normally be graded but will not necessarily receive any points – it helps to get instructor approval prior to the late assignment. Students are encouraged to discuss homework *verbally* with each other, but you may not work together when preparing written answers – nor may written answers be compared. Violation of this policy will be treated as an Academic Integrity matter.

Integrity: PSU defines academic integrity as the pursuit of scholarly activity in an open, honest and responsible manner. All students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts. Dishonesty of any kind will not be tolerated in this course. Dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will receive academic sanctions and will be reported to the University's Office of Student Conduct for possible further disciplinary sanctions.

Accessibility: Penn State welcomes students with disabilities into the University's educational programs. The Office for Disability Services (ODS) can help with accommodations: www.equity.psu.edu/ods/guidelines. If the documentation supports your request for reasonable accommodations, ODS will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible.

Counseling and Psychological Services: Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

Counseling and Psychological Services at University Park (CAPS): 814-863-0395
<http://studentaffairs.psu.edu/counseling/>

Penn State Crisis Line (24 hours/7 days/week): 877-229-6400

Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741

Educational Equity/Report Bias: Penn State takes great pride to foster a diverse and inclusive environment for students, faculty, and staff. Acts of intolerance, discrimination, or harassment due to age, ancestry, color, disability, gender, gender identity, national origin, race, religious belief, sexual orientation, or veteran status are not tolerated and can be reported through Educational Equity via the Report Bias webpage (<http://equity.psu.edu/reportbias/>).