ASEN 6080: Statistical Orbit Determination
Syllabus, Spring 2025

Lecture: Tuesday/Thursday, 1:00 - 2:15 PM, AERO 114

Instructors

Prof. Jay McMahon
Office: AERO / Email: jay.mcmahon@colorado.edu

Course Website

https://canvas.colorado.edu

This semester we will be using Canvas, CU Boulder?s new learning management system. We will be using Canvas for posting all class information (assignments, notes, slides); work will also be turned in and returned through this site. There will also be a discussion board that will be used.

To access Canvas, go to: https://canvas.colorado.edu. Log-in using your CU login name and IdentiKey password.

Once you log-in, click on ASEN6080 to go into our course.

Make the most out of Canvas by downloading the Canvas Student App to view your grades, view course materials, submit assignments, take quizzes, and more.

Subscribing to notifications to be reminded of due dates, receive announcements, and grades. Browsing the Canvas Guides or help videos for information on how to use Canvas. If you run into any problems, click the Help Icon within Canvas to report a problem or chat 24x7 with Canvas Support.

For additional assistance, contact the IT Service Center at help@colorado.edu or 303-735-4357.

Course Text

Required:

Statistical Orbit Determination, Byron D. Tapley, Bob E. Schutz, and George H. Born, 2004.

Not required, but recommended and available for free through library (links on web site):

Optimal Estimation of Dynamic Systems, John Crassidis and John Junkins, 2004.

Applied Optimal Estimation, Edited by A. Gelb, 1974.

Cheap (in Dover) and worth buying for reference:

Factorization Methods for Discrete Sequential Estimation, Gerald J. Bierman, 2006.

Stochastic Processes and Filtering Theory, Andrew H. Jazwinski, 2007.

Course Description

ASEN 6080 is a course providing an in-depth discussion of advanced orbit determination techniques. The focus is on the fundamentals of these methods based on non-linear estimation theory.

Course Format

The course will consist of two weekly lectures, homework and a final project. Lecture attendance is highly recommended since many topics are not covered in the course textbook. The final project will be assigned mid-semester, and will be due at the end of the semester (exact date to be announced). Project presentations will be held the last week of class or during the finals week (TBD) and will count toward the 10% participation grade.

Collaborative study and exploration of the course material is highly encouraged.

Course Grading

Project 1	25%
Project 2	35%
Homework	40%

Homework

Each homework is due at/by the beginning of lecture on the specified due date. Late assignments will not be accepted unless there are extenuating circumstances (at my judgement).

Homework grading is on a scale of 0 $\rightarrow$ "✓-" $\rightarrow$ "✓" $\rightarrow$ "✓+" scale as follows.

- 0 = assignment not turned in
- "✓-" = assignment turned in, but either not complete or with major errors
- "✓" = assignment turned in complete
- "✓+" = assignment turned in complete with above average effort/analysis

It is expected that students will generally get a "✓" or "✓+" on all assignments. Averaging above a "✓" for the term will receive all homework points.

Projects

There are two projects in this course. They both require significant coding effort and analysis. The details will be released later in the semester. See the class schedule for the timing of the projects.

Discussion

Use Slack! Details to come via Canvas.

It is often the case that you can explain things better to one another than I will explain them to you - I want you to all take advantage of this. Furthermore, just because you think you understand something

doesn't mean you should stop thinking about it - ask any professor and they will tell you that mastering material reaches a new level once you *teach* it.

1 University Policies

This class will be conducted in accordance with university policies:

1.1 Honor code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. Understanding the course's syllabus is a vital part in adhering to the Honor Code.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

1.2 Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website (`www.colorado.edu/disabilityservices/students`). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see Temporary Medical Conditions on the Disability Services website.

If you have a temporary illness, injury or required medical isolation for which you require adjustment, please discuss with Prof. McMahon.

1.3 Accommodation for Religious Obligations

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, you must let the instructors know of any such conflicts within the first two weeks of the semester so that we can work with you to make reasonable arrangements. See the campus policy regarding religious observances for full details.

1.4 Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

1.5 Classroom Behavior

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, marital status, political affiliation, or political philosophy.

For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

1.6 Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email CUreport@colorado.edu. Information about university policies, reporting options, and OIEC support resources including confidential services can be found on the OIEC website.

Please know that faculty and graduate instructors are required to inform OIEC when they are made aware of incidents related to these concerns regardless of when or where something occurred. This is to ensure that individuals impacted receive outreach from OIEC about their options and support resources. To learn more about reporting and support for a variety of concerns, visit the Don?t Ignore It page.

1.7 Mental Health and Wellness

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.

1.8 Acceptable Use of AI in this Class

Use it however you want, just be aware of the fact that if you count on it too much, you might not learn as much about the material yourself!

ASEN 6080 Course Schedule - Spring 2025						
Week	**Class Date**	**Lec. #**	**Topic(s)**	**Read**	**HW Assign**	**HW Due**
1	Tue, Jan 14	1	Intro to OD	Chpt 1	1, 2	
Jan 13, 2025	Thu, Jan 16	2	Basic Filters (CKF, EKF, batch)	4.3 - 4.7		
2	Tue, Jan 21	3	Dynamics	Chpt 2, 4.2		
Jan 20, 2025	Thu, Jan 23	4	Measurements	Chpt 3		
3	Tue, Jan 28	5	Coding Best Practices, SPICE			1
Jan 27, 2025	Thu, Jan 30	6	Parameter Estimation & Observability	4.12		
4	Tue, Feb 4	7	SNC & DMC	4.10, App F	Project 1	2
Feb 3, 2025	Thu, Feb 6	8	Square root methods, Potter, UD, QR			
5	Tue, Feb 11	9	Smoothing	4.15		
Feb 10, 2025	Thu, Feb 13	10	Smoothing	4.15		
6	Tue, Feb 18	11	Information filters, SRIF	4.10, 5.10, 5.11	3	Project 1
Feb 17, 2025	Thu, Feb 20	12	Information filters, SRIF	4.10, 5.10, 5.11		
7	Tue, Feb 25	13	Muti-arc Filtering	Papers	4	3
Feb 24, 2025	Thu, Feb 27	14	Uncertainty Propagation, Monte Carlo			
8	Tue, Mar 4	15	UKF	Papers	5	4
Mar 3, 2025	Thu, Mar 6	16	UKF	Papers		
9	Tue, Mar 11	17	Covariance Analysis	Chpt 6	6	5
Mar 10, 2025	Thu, Mar 13	18	Consider Parameters	Chpt 6		
10	Tue, Mar 18	19	Consider Parameters	Chpt 6		6
Mar 17, 2025	Thu, Mar 20	20	Interplanetary Nav, B-Plane	Papers	Project 2	
11	Tue, Mar 25	Spring Break				
Mar 24, 2025	Thu, Mar 27					
12	Tue, Apr 1	21	OD Analysis Methods		7	
Mar 31, 2025	Thu, Apr 3	22	Pseudo-Epoch State Filter & stochastics			
13	Tue, Apr 8	23	IOD	Papers	8	7
Apr 7, 2025	Thu, Apr 10	24	Iterated Kalman Filter			
14	Tue, Apr 15	25	Higher-order Kalman Filters	Papers		8
Apr 14, 2025	Thu, Apr 17	26	Gaussian Mixture Models	Papers		
15	Tue, Apr 22	27	Particle Filters	Papers		
Apr 21, 2025	Thu, Apr 24	28	MCMC, ML methods	Papers		
16	Tue, Apr 29	29	SLAM	Papers		
Apr 28, 2025	Thu, May 1	30	OREx Radio Science			Project 2
No Final!						