

## EML 6352: Optimal Estimation and Kalman Filtering

**Class Periods:** MWF, Period 6 (12:50 PM - 1:40 PM)

**Locations:** NEB 0102

**Academic Term:** Spring 2024

*It may become necessary to modify this syllabus during the semester.  
In this event, students will be notified, and the revised syllabus will be posted on the course website.*

### **Instructor:**

Name: Yu Wang

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Office Phone Number: 352-846-3599

Office Location: MAE-B 330

### **Teaching Assistant/Peer Mentor/Supervised Teaching Student:**

To be announced on CANVAS

### **Course Description**

Fundamentals of probability and its applications to linear system estimation (3 Credit Hours)

### **Course Pre-Requisites / Co-Requisites**

Familiarity with linear algebra and linear systems theory through one of the following courses is recommended:

EML 5311 (MAE: Control System Theory)

EEL 5544 (ECE: Noise in Linear Systems)

EEL 5182 (ECE: State Variable Methods)

MAD 6406 (MATH: Numerical Linear Algebra)

### **Course Objectives**

The purpose of this course is twofold: (1) provide a firm background in parameter and state estimation methods, and (2) provide training on how to (and how not to) apply them in practice. Relevance to engineering applications and fields such as control and robotics will be illustrated through examples and projects.

### **Relation to Program Outcomes (ABET):**

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	Low
3. An ability to communicate effectively with a range of audiences	
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. An ability to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Low

\*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

### **Required Textbooks and Software**

- No textbook is required. Suggested reading materials will be provided throughout the lectures.
- The following books are good references:
  - probability and signals: *Leon-Garcia, Probability and Random Processes for Electrical Engineering*
  - classification and decision: *Duda, Hart and Stork, Pattern Classification*
  - continuous estimation: *Kay, Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory* and *Bar-Shalom et al, Estimation with Applications to Tracking and Navigation*
  - LQG and H2 control: *Burl, Linear Optimal Control*

### **Required Computer:**

This is discussed on both the department and college websites:

- <https://www.eng.ufl.edu/students/resources/computer-requirements/>
- <https://mae.ufl.edu/academics/prospective/undergraduate/computer-requirements/>

Bottom line: if you don't have a laptop, you need one. If you have one that works, feel free to discuss with the instructor whether it will suffice.

### **Course Schedule**

- Review of Linear Algebra: Least Squares Solution of Linear Equations.
- Probability and Random Variables: Combinatorics, Probability Spaces, Random Variables, Density Functions, Moments, Joint Density Functions, Independence, Conditional Density, etc.
- Estimation: Best Linear Unbiased Estimator, Least Squares Estimator, Maximum Likelihood Estimator, Maximum A-Posteriori Estimators, Unbiasedness and Consistency, Cramer-Rao Lower Bound, etc.
- Filtering: Discrete-Time Kalman Filter, Extended Kalman Filter, Prediction and Smoothing, etc.

\* The schedule is only tentative and may be subject to further changes.

### **Important Dates:**

Homework: due every two weeks  
Exam 1: first third of the semester  
Exam 2: second third of the semester  
Final Exam: end of the semester

\* Corrections of grades should be submitted promptly within 5 business days of the grade posting in writing with a concise statement of why you believe there has been an error. Note that the professor has the final determination in the grade assigned.

### **Attendance Policy, Class Expectations, and Make-Up Policy**

You are responsible for participating, staying up-to-date on all announcements, in-class lectures, posted video lectures, reading assignments, homework, and quizzes. Course notes will not always be supplied on the Canvas webpage. **Only one** late homework will be accepted. Late quizzes will not generally be accepted. Makeups and makeup exams are only allowed for students with extreme, documented circumstances. Students must contact the instructor as soon as possible to provide documentation and request a make-up exam. Final exam is required and there is no make-up final. Note: club sport activities are not excused absences, personal vacations are not excused absences, job interviews are not excused absences.

Excused absences must be consistent with university policies in the Graduate Catalog (<https://catalog.ufl.edu/graduate/regulations>) and require appropriate documentation. Additional information can be found here: <https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

### ***Evaluation of Grades***

<b>Assignment</b>	<b>Total Points</b>
Homework	10%
Participation	10%
Exam 1	20%
Exam 2	20%
Final Exam	40%
<b>Total:</b>	<b>100%</b>

### ***Grading Policy***

<b>Percent</b>	<b>Grade</b>	<b>Grade Points</b>
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

### ***Students Requiring Accommodations***

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

### ***Honorlock***

Consistent with University of Florida policy, Honorlock will be used for the mid-term exams and the final. Please see the following link: <https://distance.ufl.edu/proctoring/> for more information.

### ***Course Evaluation***

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

### ***In-Class Recording***

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in

connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

### ***Use of Live Zoom (HyFlex)***

The objectives are to meet in-person for lecture and to use Honorlock for exams and office hours. These objectives may change during the semester. In light of the challenge of the pandemic, the instructor may live stream to those who are sick or just quarantining. Associated recordings may be made. Regarding associated details, the instructor will update the class throughout the semester.

### ***University Honesty Policy***

In this class, use of unauthorized aid, copying of homework, sharing of files (Solidworks or reports), dishonest attendance logging (in-class Quizzes, Webgems) are considered honor code violations. (If you are leaving class early or leaving our Zoom meeting, fine. Do not log attendance. Logging and leaving is an honor code violation.)

Honor code violation can result in “E” for the course, even if it’s your first offense. UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel (e.g. the instructor). A violation of the honor code will result in academic sanctions (typically a failing grade “E” assigned for the course) and further disciplinary action. If you have any questions or concerns, please consult with the instructor in this class.

### ***Commitment to a Safe and Inclusive Learning Environment***

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Undergraduate Program Coordinator: [advising@mae.ufl.edu](mailto:advising@mae.ufl.edu)
- Jennifer Nappo, Director of Human Resources, 352-392-0904, [jpennacc@ufl.edu](mailto:jpennacc@ufl.edu)

- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

### ***Software Use and Copyrighted Material***

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use and the use of copyrighted material. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

### ***Student Privacy***

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

### ***Online Course Recording***

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Office hour sessions may likewise be audio visually recorded.

Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. Students who are in class likewise agree to have their voices recorded.

### ***Campus Resources:***

#### ***Health and Wellness***

##### **U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

##### **Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

##### **Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

## COVID-19

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email [covid@shcc.ufl.edu](mailto:covid@shcc.ufl.edu)) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the [UF Health Screen, Test & Protect website](#) for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.
- Consistent with UF policy: "If a student is absent from classes or examinations because of illness, they should contact their instructors."
- If you contract Covid-19 during the semester, the instructor pledges to help you to the extent possible, to help you learn and manage your assignments. Letting the instructor know is step one.

## Academic Resources

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio**, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus**: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.