

SUR 6535 GPS-INS Integration

1. OVERVIEW

From airplanes, drones, to autonomous vehicles, GNSS-aided inertial navigation systems are bringing new conveniences to modern society. This course includes the principles of inertial navigation and its integration with GPS, coordinate frames, modeling linear motion and rotational motion, mechanization of inertial navigation sensor measurements, space state representation of system errors, linear state equations, and practical Kalman filter techniques.

- Spring semester 2024, 3 credits.
- In-person for the Gainesville campus, synchronous lectures through Zoom for remote students (<https://ufl.zoom.us/my/chunli>).
- <http://elearning.ufl.edu/>

Course Prerequisites: Measurement Science SUR 3520 and Geodesy and Geodetic Positioning SUR 4530, or instructor consent. This course requires a background in differential and integral calculus and matrix algebra, as well as MATLAB or Python experience.

Instructor:

Dr. Chunli Dai, 406B Reed Lab, Gainesville, FL.
Office: 352-392-4998; email: chunlidai@ufl.edu

Time and location:

Lectures: Thursdays, 8:30 am to 10:25 am (Periods 2 and 3), at Reed Lab 302.

Labs: Thursdays, 3:00 pm to 4:55 pm (Periods 8 and 9), at Reed Lab 302.

First day of class: January 11, 2024. Last day of class: April 18, 2024.

Office hours: Thursdays, 11 am to 12 pm. Other times by appointment.

Exam dates:

Mid-term exam: Thursday, March 7, 2024, 8:30 am to 10:25 am (Honorlock).

Final exam: Thursday, May 2, 2024, 12:30 pm to 2:30 pm (Honorlock).

Recommended Textbooks (Optional):

Jekeli, Christopher, (2023). Inertial Navigation Systems with Geodetic Applications. The 2nd edition. De Gruyter.

Free electronic book at

<https://www.degruyter.com/document/doi/10.1515/9783110784329/html>. Please use the **UF VPN for free access** if you are off campus.

Hardcopy is \$190, Kindle is \$168 at https://www.amazon.com/Inertial-Navigation-Systems-Geodetic-Applications-dp-3110784211/dp/3110784211/ref=dp_ob_title_bk.

2. LEARNING OUTCOMES

At the completion of this course, the student should be able to:

- understand the concepts in coordinate systems, linear differential equations, and stochastic processes
- understand the fundamentals of GPS-aided inertial navigation systems
- identify the essential components of IMUs
- understand and solve navigation equations in different frames
- understand how sensor errors propagate through the system to navigation errors
- apply Kalman Filter for related problems
- analyze GPS/INS data for precise positioning and navigation
- understand INS/GPS gravimetry
- demonstrate communication skills in interpreting results

3. COURSE LOGISTICS

- There is a 1-week turnaround for assignment and discussion grading.
- Assignments are graded based on timeliness, the correctness of computations, and the interpretation of results. Discussion items are graded based on creativity, completeness, and technical correctness.
- The Canvas system should be used as the primary platform for written communication between students and the instructor. Questions and suggestions to the whole class can be posted under the Discussion tab.

Technology Requirements:

- A computer with a high-speed internet connection and a supported browser (Google Chrome) for the online exams through Honorlock.
- For remote students: headset and microphone.

4. GRADES AND GRADING SCALE

Item	Percentage
Timeliness and quality of assignments (5 lab assignments)	30%
Online discussion (1 discussion)	10%
Mid-term exam	30%
Final exam (cumulative)	30%
Total	100%

Final grading follows University standards based on the following scale

(<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>):

Letter Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	E
Course Score	93.0-100	90.0-92.9	87.0-89.9	83.0-86.9	80.0-82.9	77.0-79.9	73.0-76.9	70.0-72.9	67.0-69.9	63.0-66.9	60.0-62.9	0-59.9
Grade Points	4	3.67	3.33	3.0	2.67	2.33	2.0	1.67	1.33	1.0	0.67	0

5. COURSE SCHEDULE

Week	Topic	Details
Week 1	Introduction	
Week 2	Coordinate Frames and Transformations	Chapter 1
Week 3	Inertial Measurement Units 1	Chapter 3
Week 4	Inertial Measurement Units 2	Chapter 3
Week 5	Inertial Navigation System	Chapter 4
Week 6	System Error Dynamics	Chapter 5
Week 7	Stochastic Models	Chapter 6
Week 8	Linear Estimation 1 (Least Squares Adjustment)	Notes
Week 9	Midterm exam	
Week 10	Spring break	
Week 11	Linear Estimation 2 (Kalman Filter)	Chapter 7.4-7.7
Week 12	INS Initialization and Alignment	Chapter 8
Week 13	The Global Positioning System (GPS)	Chapter 9
Week 14	Geodetic Application 1	Chapters 10.1-10.3
Week 15	Geodetic Application 2	Chapter 10.4

6. POLICIES AND REQUIREMENTS

Guidelines for preparing homework assignments:

- a) You may work together and discuss the assignments, but you must prepare your own report, which includes your own discussions, your own derivations of equations, and your own graphical illustrations.
- b) The lab report must be type-written. Good English needs to be practiced.
- c) Label and define everything. Symbols that you use in your text must be properly defined. Axes in plots need to be properly labeled. Units must be denoted for all numerical values, including plotted values.
- d) Graphical illustrations (plots) need to be legible. Spend time to make your plots meaningful and informative. Use appropriate ranges on the abscissa and ordinate axes to show the important parts of what should be plotted.

Late submissions and make-up requests:

It is the responsibility of the student to access online materials (assignments, discussions, exams) to maintain satisfactory progress in the course.

- A 10% penalty will be applied to the late assignments.
- Exams can only be taken during the designated times.
- Exceptions to the late policy are only allowed per university policy.
- Any late submission due to technical issues Must be accompanied by the ticket number received from the Helpdesk when the problem was reported to them. The ticket number should document the time and date of the problem. You must email your instructor within 24 hours of the technical difficulty if you request consideration.

For computer, software compatibility, or access problems call the HELP DESK phone number—352-392-HELP = 352- 392-4357.

Requirements for class **attendance** and make-up exams, assignments and other work are consistent with university policies that can be found at:

<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

Semester Evaluation Process:

Student assessment of instruction is an important part of efforts to improve teaching and learning.

At approximately the mid-point of the semester, the School of Forest Resources & Conservation will request anonymous feedback on student satisfaction on various aspects of this course. These surveys will be sent out through Canvas and are not required but encouraged. This is not the UF Faculty Evaluation!

At the end of the semester, 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/>.

Academic Honesty Policy:

As a student at the University of Florida, you have committed yourself to upholding the Honor Code, which includes the following pledge: ***“We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity.”***

You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit 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.”***

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct or appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated.

Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: <http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code>

University Policy on Accommodating Students with Disabilities:

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center. Click [here](#) to get started with the Disability Resource Center. 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.

Software use:

All faculty, staff, and students of the university are required and expected to obey the laws and legal agreements governing software use. 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.

Class recordings:

Policies regarding student in-class recordings and publishing them are detailed here: <https://aa.ufl.edu/policies/in-class-recording/>

7. CAMPUS RESOURCES

Student Life, Wellness, and Counseling Help:

- *U Matter, We Care*: If you or someone you know is in distress, please contact umatter@ufl.edu, 352-392- 1575, or visit [U Matter, We Care website](#) to refer or report a concern and a team member will reach out to the student in distress.
- *Counseling and Wellness Center*: [Visit the Counseling and Wellness Center website](#) or call 352-392- 1575 for information on crisis services as well as non-crisis services.
- *Student Health Care Center*: Call 352-392-1161 for 24/7 information to help you find the care you need, or [visit the Student Health Care Center website](#).
- *University Police Department*: [Visit UF Police Department website](#) or call 352-392-1111 (or 9-1-1 for emergencies).
- Career Resource Center <https://career.ufl.edu/>
- GatorWell Health Promotion Services <https://gatorwell.ufsa.ufl.edu/>

Academic Resources:

- For issues with technical difficulties for e-learning in Canvas, please post your question to the Technical Help Discussion in your course, or contact the UF Help Desk at: Learning-support@ufl.edu | (352) 392-HELP - select option 2 | <http://elearning.ufl.edu> | <https://helpdesk.ufl.edu/>
- SFFGS Academic Hub <https://ufl.instructure.com/courses/303721>
- [Career Connections Center](#): Reitz Union Suite 1300, 352-392-1601. Career assistance and counseling services.
- [Library Support](#): Various ways to receive assistance with respect to using the libraries or finding resources.
- [Teaching Center](#): Broward Hall, 352-392-2010 or to make an appointment 352- 392-6420. General study skills and tutoring.
- [Writing Studio](#): 2215 Turlington Hall, 352-846-1138. Help brainstorming, formatting, and writing papers.
- Student Complaints On-Campus: [Visit the Student Honor Code and Student Conduct Code webpage for more information](#).
- On-Line Students Complaints: [View the Distance Learning Student Complaint Process](#).