

Course Outline for 525.445, Modern Navigation Systems

August 2018

This outline provides an overview of the course and assignments by week. Please remember to check the calendar, assignments page, and announcements for specific due dates.

Each course module runs for a period of seven (7) days, i.e., one week. Due dates for assignments are typically two weeks after the start of the module, allowing 1 – 2 online office hour sessions for questions for each assignment. Modules will typically be released about 1 week ahead of the day that the module begins.

Note that even when module contents are not highlighted in the readings, it is typical for a module to contain significant textual information derived from, for example, the optional textbooks. Hence, students should watch the recorded module presentations and download the corresponding ppt files to use as supplemental reading.

Also, supplemental technical papers and videos will be uploaded to the site as additional reference material, and will be identified in the relevant module slides and presentations.

Finally, module discussions are not limited in any manner. The discussion topics listed below are simply a starting point. Students can always originate their own discussion threads.

Module	Dates	Topics	Assignments
Module 1	Mon 8/27/18– Sun 9/02/18	Course summary and historical perspective	Readings (Kayton, Chapters 1 & 2) <ul style="list-style-type: none">• Assignment: background questions about navigation• Discussion: general questions about the history of navigation
Module 2	Mon 9/03/18– Sun 9/09/18	Orbits, vectors, and coordinate systems	Readings (Kayton, Chapter 2) <ul style="list-style-type: none">• Assignment: rotation of axes; great versus small circles; vector mathematics• Discussion: mathematics of vectors; review of trigonometry
Module 3	Mon 9/10/18– Sun 9/16/185	Spherical trigonometry & perturbation theory for solving great and small circle problems on or near the surface of the earth	Readings (Kayton, Chapter 2, mod 3 slides) <ul style="list-style-type: none">• Assignments: circles & tangents; Mason-Dixon calculation; perturbation theory• Discussion: spherical trigonometry and perturbation theory

Module	Dates	Topics	Assignments
Module 4	Mon 9/17/18– Sun 9/23/18	Newton's Method	Readings (Wikipedia; mod 4 slides) <ul style="list-style-type: none"> • Assignment: Newton's method computations in one and two dimensions • Discussion: how to write code for Newton's method using Excel
Module 5	Mon 9/24/18– Sun 9/30/18	Position determination of satellites, planets, and stars in earth-centered coordinate systems	Readings (Kayton, chapters 5, 6, & 12; Nautical Almanac, Rey, entire book) <ul style="list-style-type: none"> • Assignments: pendulum, look angles, star locations • Discussion: orbital elements; computations; finding the stars
Module 6	Mon 10/01/18– Sun 10/07/18	Orbit propagator	Readings (Kayton, chaps. 5, 7 and 12) <ul style="list-style-type: none"> • Assignment: write an orbit propagator in Excel • Discussion: How to write and use orbit propagators
Module 7	Mon 10/08/18– Sun 10/14/18	Lines of position and weighted least squares	Readings (Kayton, chapter 3 and module 7 slides) <ul style="list-style-type: none"> • Assignment: define and solve a weighted least squares problem • Discussion: least squares; inner products versus outer products
Spring Break	Tue 03/16/15– Mon 03/23/15	No module release!	Relax; catch up on previous modules
Module 8	Mon 10/15/18– Sun 10/21/18	Sextant navigation	Readings (Kayton, chapter 5; Nautical Almanac, tutorial section) Videos: sextant navigation; excerpt from <i>All is Lost</i>. <ul style="list-style-type: none"> • Assignment: sextant problem • Discussion: why the sextant algorithm works Project Milestones/Deliverables: submit a short paragraph describing one or more ideas for your research project
Module 9	Mon 10/22/18– Sun 10/28/18	Satellite navigation using geostationary satellites	Readings (Kayton, chaps. 5, 6, 7, & 12) <ul style="list-style-type: none"> • Assignment: position determination from satellite look angles and/or ranges • Discussion: how to apply Newton's method to satellite navigation problems

Module	Dates	Topics	Assignments
Module 10	Mon 10/29/18– Sun 11/04/18	Solving for time and the method of lunars	<p>Readings (Kayton, chaps. 5 & 12; supplemental papers posted to Blackboard)</p> <ul style="list-style-type: none"> • Assignment: solving for time using lunars • Discussion: Harrison, Maskelyne, and the longitude problem <p>Project Milestones/Deliverables: submit a short paragraph describing the final topic of your research project</p>
Module 11	Mon 11/05/18– Sun 11/11/18	Navigating with GPS	<p>Readings (Kayton, chaps 5, 10 & 12, Nautical Almanac; module slides)</p> <p>Video: Cospas-Sarsat</p> <ul style="list-style-type: none"> • Assignment: modify the sextant assignment to solve for position using GPS satellite ranging and angle data • Discussion: parallax; Doppler, use of ranges versus use of angles
Module 12	Mon 11/12/18– Sun 11/18/18	Inertial navigation	<p>Readings (Kayton chapter 7 & chapter 5)</p> <p>Videos: MEMs inertial sensors; angular momentum at the circus</p> <ul style="list-style-type: none"> • Assignment: inertial sensors and atomic clocks • Discussion: inertial sensors and chip scale atomic clocks <p>Project Milestones/Deliverables: students can submit research report in this or the following weeks; present during office hours</p>
	11/19 – 11/25	Thanksgiving	Nothing assigned or due
Module 13	Mon 11/26/18– Sun 12/02/18	Avionics systems and radio navigation	<p>Readings (Kayton, 8 – 11, 13)</p> <p>Video: shipborne navigation</p> <ul style="list-style-type: none"> • Assignment: position fix using GPS equations with parallax = 1 • Discussion: the navigation equations in the three different parallax regimes <p>Project Milestones/Deliverables: students can submit research report in this or the following week; present during office hours</p>

Module	Dates	Topics	Assignments
Module 14	Mon 12/03/18– Sun 12/09/18	Simulated flight	<p>Readings (excerpts of Cessna manual, uploaded to Blackboard)</p> <p>Video: aircraft operations</p> <ul style="list-style-type: none"> • Assignment: write a flight plan • Discussion: lessons learned from comparing the flight plan to the simulation <p>Project Milestones/Deliverables: final week to submit research report and present during office hours</p>