525.445 Modern Navigation Systems

Syllabus

Instructor Contact

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I prefer that students contact me via email or by leaving a voice message at 240-228-6907, which will be forwarded to my email automatically. Please be sure to include the course number in the subject line. I will make every effort to respond to your inquiry the same day. If an issue is urgent, please indicate "urgent" within the subject line of the email and I will respond as soon as is practical. I occasionally lose student emails in the deluge of daily messages, so please don't hesitate to send a reminder, or to email and phone.

Office Hours via Adobe Connect

For more information regarding Adobe Connect, please see the Adobe Connect Information page located in Help & Support on the left menu.

This course will use Adobe Connect to facilitate weekly and occasionally twice-weekly, synchronous office hours. You are not required to participate in office hours; however, you may find them very beneficial for receiving more timely answers to questions related to the course content and assignments.

During the first week of the course I will conduct a student survey to determine the best days and times of the week to schedule the office hours. Office hours will typically be the same time and day each week, but might vary occasionally, or there might be an additional, short notice additional sessions in response to student requests.

Once the day and time have been determined, I will post an announcement with the details. In addition, I will also send announcements prior to each office hour session so that students will receive an email with the specific link for that session. Students will click that link to access Adobe Connect and participate in the office hours. You are encouraged to post any questions they would like to have answered during the live office hour sessions to the relevant discussion module discussion area, or email the questions to the instructor. Recorded office hour sessions will be posted as announcements, with automatic emails to students, for any students who were unable to participate in the "live" sessions or for students who like to listen to them again.

Course Description

The course explores the use of satellite, terrestrial, celestial, radio, magnetic, and inertial systems for the real-time determination of position, velocity, acceleration, and attitude. Particular emphasis is on the historical importance of navigation systems; avionics navigation systems for high-performance aircraft; the Global Positioning System; the relationships between navigation, cartography, surveying, and astronomy; and emerging trends for integrating various navigation techniques into single, tightly coupled systems.

Prerequisites

There are no special prerequisites.

Course Goals

To understand and be able to use the fundamentals of navigation on, above, or away from the spherical earth using techniques developed over the past several hundred years as implemented using modern technology.

Course Objectives

By the end of this course, you will be able to:

1. Describe, compare, and reproduce the historical measurements and computations of Newton, Mason & Dixon, Lewis and Clark and others with respect to astronomy, surveying, and navigation.
2. Derive the Keplerian orbital parameters and equations from the basic physics of force and momentum and compute the locations versus time, in spherical and Cartesian coordinate systems, of earth orbiting satellites, the earth's moon, the moons of Jupiter and other planets, and the orbits of the planets around the sun.
3. Use angle measurements obtained from sextant observations of the stars to solve these equations and determine one's position on the surface of the earth. Convert the Keplerian orbital equations into the navigation equations of the Global Positioning System, and use measurements of time and distance, to solve these equations and determine one's position on the surface of the earth.
4. Use the Keplerian equations to create algorithms applicable to the navigation, guidance, and control avionics of a typical (e.g., Cessna 172) small civil aircraft.
5. Review the historical and modern technologies used for radio, optical, inertial, magnetic, and celestial navigation.
6. Define and execute an original research project that builds on and extends the skills learned above.

Course Structure

The course materials are divided into modules which can be accessed by clicking Course Modules on the left menu. A module will have several sections including the overview, content, readings, discussions, and assignments. You are encouraged to preview all sections of each module before starting. Most modules run for a period of seven (7) days, exceptions are noted on the Course Outline page. You should regularly check the assignment pages on Blackboard/Learn for assignment due dates.

Textbook

Required

Kayton, M. and Fried, W. (1997). *Avionics navigation systems* (2nd ed.). Hoboken, NJ: Wiley-Interscience.

ISBN-10: 0471547956
ISBN-13: 978-0471547952

U.S. Naval Observatory (2017). *Nautical almanac 2017* (commercial ed.). Arcata, CA: Paradise Cay Publications.

- **ISBN-10:** 1937196550 (updated to 2017 edition)
- **ISBN-13:** 978-1937196554

Rey, H.A., (2008). *The stars* (2nd ed.). Boston, MA: HMH Books for Young Readers.

ISBN-10: 0547132808
ISBN-13: 978-0547132808

Textbook information for this course is available online through the appropriate bookstore website: For online courses, search the MBS website at http://ep.jhu.edu/bookstore.

Optional

Several other books of interest are listed in the Module 1 PowerPoint presentation slides.

Required Software

Excel, MATLAB, or any other standard computational package will be needed for several of the assignments.

The MATLAB Total Academic Headcount (TAH) license is now in effect. This license is provided at no cost to you. Send an email to software@jhu.edu to request your license file/code. Please indicate that you need a standalone file/code. You will need to provide your first and last name, as well as your Hopkins email address. You will receive an email from Mathworks with instructions to create a Mathworks account. The MATLAB software will be available for download from the Mathworks site.

Technical Requirements

You should refer to Help & Support on the left menu for a general listing of all the course technical requirements.

Student Coursework Requirements

It is expected that each module will take approximately 7-10 hours per week to complete. Here is an approximate breakdown: reading the assigned sections of the texts (approximately 2 hours per week) as well as some outside reading, listening to the audio annotated slide presentations (approximately 2 hours per week), and problem solving assignments (approximately 3-6 hours per week).

This course will consist of three basic student requirements:

1. **Preparation and Participation (Module Discussions and office hour attendance and participation; 20% of Final Grade Calculation)**

   You are responsible for carefully reading all assigned material and being prepared for discussion. The majority of readings are from the required course texts. Additional reading of material posted to the Blackboard site may be assigned to supplement text readings.

Reviewing and participating in module discussions is important. However, gratuitous submissions are never needed. There will be plenty to discuss without inventing work or tabulating submissions. Nevertheless, all students are expected to participate in a meaningful manner in the discussion for a and to join at least 25% of live office hours on a regular basis (even though office hours sessions will be recorded for later viewing). This will constitute 20% of your grade.

I will monitor module discussions and will respond with comments to each thread, although not necessarily to each posting within a thread.

2. **Assignments** (50% of Final Grade Calculation)

   Several of the homework assignments will require detailed mathematical derivations and computations involving vectors, spherical trigonometry, orbitology, perturbation theory, Newtonian mechanics, and the use of Newton's method for solving systems of nonlinear equations.

   Additional assignments will include personal visual observations of the stars, planets, the International Space Station, and low earth orbiting satellites. This will lead to the sextant assignment, in which the student will reproduce the computations used for centuries by sailors at sea.

3. **The Research Project** (30% of Final Grade Calculation)

   The research project will require a trip or visit to a site important in the history of navigation (e.g., the Mason and Dixon line), or a visit to an operational facility involved with navigation, such as an airport control tower. Alternatively, students can conduct telephone or email interviews with a person or persons involved with navigation. The fundamental requirement is that students identify and use a primary, rather than secondary, source of information. Using information obtained only from secondary sources (e.g., Wikipedia or textbooks) will not be acceptable. The report will be presented online to the instructor and interested students in the form of a trip report, rather than as a traditional research paper. Emphasis will be on creativity and originality, in contrast to the highly mathematical nature of the traditional homework assignments.

   Some students will find individual assignments to be more difficult than students whose background or level of experience is different. When needed, extra time will generally be provided, and students need not fret if it takes multiple attempts and extended deadlines to succeed at some of the more complex assignments. But, end of term submissions of assignments that are well past their deadline will be penalized.

Grading

Assignments are due according to the dates posted on the Blackboard course site. A grader or I will post grades one week after assignment due dates. If you disagree with the grader's assessment, please let me know by email or telephone. There is never a need to fret over these things. The course is supposed to be fun. Enjoy it.

I generally do not directly grade spelling and grammar. However, egregious violations of the rules of the English language will be noted, sometimes with detailed comments. Consistently poor performance in either spelling or grammar may detract from your grade.

Grading of Assignments

Assignments are evaluated by the following grading elements:

1. The problem being addressed should be restated succinctly, and each part of the assignment must be addressed in appropriate detail.
2. Getting the correct answer is important, but understanding the approach is often more important. Explain your approach. If you are unable to solve the problem, comment on what difficulties you encountered.
3. Provide enough details such that a person knowledgeable in the field can repeat the work is essential. Explain key equations. Don't just submit equations and calculations without exposition of what you are doing and why.
4. Acknowledge assistance provided **to or from** others. Avail yourself of help when needed. The rationale for believing the answer to a problem is correct should be provided.
5. Perform and explain a back of the envelope "sanity check" to identify any glaring errors in the primary analysis. This can typically be done in a phrase or sentence.
6. Cite outside references are included when appropriate. The absence of needed citations is usually obvious to the grader(s).
7. **Plagiarism is never tolerated.** Instead, point the reader of your assignment to the appropriate reference source. Cutting and pasting of internet material is the typical issue at hand, and is often obvious to the reader.
8. Submit assignments as a single .doc, .docx, or .pdf file unless other permitted (e.g., when a spread sheet can be submitted). Cut and paste results from other files into the word or pdf file. **Include your last name and the assignment number in the file name.**
9. Under no circumstances submit large lists of numbers produced by MatLab or Excel. Submit tables, graphs, and graphics that have been properly edited instead. All graphs must have meaningful axes labels, and all tables, graphs, and graphics must have first-rate captions.
10. Handwritten submissions scanned into pdf files are always acceptable, as is the use of cursive. This is not a typing course.

Assignments are graded as follows unless a separate grading rubric is provided with an atypical assignment. For example, the modification and use of a spreadsheet provided by the instructor for predicting the orbital behavior of a satellite warrants a separate rubric due to the special nature of the assignment.

9 – 10: high A, meaning that the work exceeds expectations. This means that all 10 grading elements have been addressed for each problem in the assignment.

8: low A, meaning that the work is acceptable and no resubmission is needed. This means that all but one or two of the grading elements have been addressed.

6 – 7: B, meaning that only one or two of the grading elements are missing, but the remaining elements are addressed in a superficial and/or incomplete fashion. The work can be improved and can be resubmitted by correcting these omissions and shortcomings.

5: Incomplete, meaning that work was submitted, but was missing more than two elements or the completion of elements was superficial and/or incomplete. The five is used as a placeholder in Blackboard, and will be turned to a 0 at the end of the term.

2. If grading elements 8 and 9 are not satisfied, the work will be assigned a placeholder grade of two and must be resubmitted before it will be graded. The grade will be turned to a 0 at the end of the term.

1. Plagiarism, which will result in follow-up discussions with the instructor, is never tolerated, and

the entire assignment will receive a grade of one as a placeholder and submitted to the department head for consideration of academic sanctions.

0: No work was submitted.

4. **The Research Project** (30% of the Final Grade Calculation)

   The research project will be assigned several weeks into the course. Students will be encouraged to share their experiences during on-line office hour sessions.

   The research project is evaluated by the following grading elements:

   1. It includes an element of exploration and uncertainty.
   2. It explores at least one significant primary source.
   3. It is relevant to the course material.
   4. The final report, using pdf, Word, or PowerPoint, explains the motivation, details, and results of the project in a succinct but understandable, and hopefully compelling way.
   5. There must be no downloads from the internet that aren't edited to meet the needs of the report and that are not properly cited. In general, downloads from the internet are neither needed nor appropriate. Provide URLs, with explanation of the significance of the material at the URL, instead.

      Note that original videos are always welcome.

      Don't ask the instructor how many pages it should be. Simply describe what you did, how you did it, what you learned, and what you would do differently next time. Keep it short.

   The Research Project requires successful completion of items 1 – 5, and will be returned for revision if it doesn't. Each item is worth 25% of the final grade of 10 points, which is then weighted to count for 30% of the final grade. Note that it is okay to "crash and burn", as long as you gave the project the effort required to satisfy items 1 – 5, above.

5. **The final grade**

A final grade for the course of A indicates achievement of consistent quality and distinction throughout the course—that is, good work in all aspects of assignments and discussion in every week.

A final grade of B indicates work that meets all course requirements on a level acceptable for graduate academic work. These criteria apply to both undergraduates and graduate students taking the course.

An A+ is given when there is some very outstanding feature of the student's work that stands out not just for effort, but for creativity, imagination, and perseverance.

Help & Support

You should refer to Help & Support on the left menu for a listing of all the student services and support available.

Policies and Guidelines

Don't fret. If you need to turn an assignment in a day or a few days late, inform me. But, this is not an urgent matter. If you get stuck or frustrated with an assignment, give it a rest and try again a day or two.

However, procrastination until the end of term is not acceptable.. Try to formulate your questions carefully, and phone or email me with them, and/or share your questions with others via the discussion modules. Significant back-channel discussions between and among students must be acknowledged, and the work submitted by a student must be his or her own work.

Academic Misconduct Policy

Collaborations and discussions between students are key ingredients to success in a graduate course. You are encouraged to discuss the course material with each other as you sort through concepts that may be difficult to comprehend or controversial. In this course, collaboration is not cheating provided that you acknowledge any assistance that you receive. If you include direct quotes from any source in your discussions, written assignments, the final exam, or any other submission, whether you will receive a grade or not, you must provide attribution.

All students are required to read, know, and comply with the Johns Hopkins University Krieger School of Arts and Sciences (KSAS) / Whiting School of Engineering (WSE) Procedures for Handling Allegations of Misconduct by Full-Time and Part-Time Graduate Students available at: https://ep.jhu.edu/wseacademicmisconductpolicy

This policy prohibits academic misconduct, including but not limited to the following: cheating or facilitating cheating; plagiarism; reuse of assignments; unauthorized collaboration; alteration of graded assignments; and unfair competition. You may request a paper copy of this policy at this by contacting Mark Tuminello
Phone 410-516-2306
E-mail mtumine2@jhu.edu

Policy on Disability Services

Johns Hopkins University (JHU) is committed to creating a welcoming and inclusive environment for students, faculty, staff and visitors with disabilities. The University does not discriminate on the basis of race, color, sex, religion, sexual orientation, national or ethnic origin, age, disability or veteran status in any student program or activity, or with regard to admission or employment. JHU works to ensure that students, employees and visitors with disabilities have equal access to university programs, facilities, technology and websites.

Under Section 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act (ADA) of 1990 and the ADA Amendments Act of 2008, a person is considered to have a disability if c (1) he or she has a physical or mental impairment that substantially limits one or more major life activities (such as hearing, seeing, speaking, breathing, performing manual tasks, walking, caring for oneself, learning, or concentrating); (2) has a record of having such an impairment; or (3) is regarded as having such an impairment class. The University provides reasonable and appropriate accommodations to students and employees with disabilities. In most cases, JHU will require documentation of the disability and the need for the specific requested accommodation. The Disability Services program within the Office of Institutional Equity oversees the coordination of reasonable accommodations for students and employees with disabilities, and serves as the central point of contact for information on physical and programmatic access at the University. More information on this policy may be found at http://web.jhu.edu/administration/jhuoie/disability/index.html or by contacting (410) 516-8075.

Disability Services

Johns Hopkins Engineering for Professionals is committed to providing reasonable and appropriate accommodations to students with disabilities.

Students requiring accommodations are encouraged to contact Disability Services at least four weeks before the start of the academic term or as soon as possible. Although requests can be made at any time, students should understand that there may be a delay of up to two weeks for implementation depending on the nature of the accommodations requested.

Requesting Accommodation

New students must submit a Student Request for Accommodation form along with supporting documentation from a qualified diagnostician that:

- Identifies the type of disability
- Describes the current level of functioning in an academic setting
- Lists recommended accommodations

Questions about disability resources and requests for accommodation at Johns Hopkins Engineering for Professionals should be directed to:

Mark Tuminello
Disability Services Coordinator
Phone 410-516-2306
Fax 410-579-8049
E-mail mtumine2@jhu.edu or ep-disability-svcs@jhu.edu