Module 1E

Modern Navigation Systems

Module Summary and Module 1 Technical Presentation

Summary of the Course Modules

- There are 14 course modules. These are listed by title on the following two slides.
- In this sub-module, we also present a brief historical perspective of and background to the course along with a first assignment and suggested reading.

Modules 1 - 7

1. Course summary and historical perspective
2. Orbits, vectors, and coordinate systems
3. Spherical trigonometry and perturbation theory for solving great and small circle problems on or near the surface of the earth.
4. Newton's Method
5. Position determination of satellites, planets, and stars in earth-centered coordinate systems.
6. Orbit propagator
7. Lines of position and weighted least squares

Modules 8 - 14

8. Sextant navigation
9. Satellite navigation using geostationary satellites
10. Solving for time and the method of lunars
11. Navigating with GPS
12. Inertial navigation, atomic clocks, and other topics
13. Avionics systems and radio navigation
14. Simulated flight

Module 1 Technical Content

- We present a very brief historical summary of navigation from the 1500's to the present with an emphasis on how navigation has found its way into our modern culture in ways we take for granted.
- The first assignment is a compendium of short answer questions that are designed to provoke your thinking and provide an overview of the many ways in which the subject material of this course overlaps, and interacts with, our culture and daily lives.

The years 1500 - 1800

- Tyco Brahe (1546 – 1601) makes and catalogs precise observations of the stars
- Kepler's laws derived and published
- In 1687, Newton publishes his Principia
  - ***Philosophiæ Naturalis Principia Mathematica***, meaning "Mathematical Principles of Natural Philosophy"
- In 1770, Mason and Dixon begin surveying the border between Maryland and Pennsylvania
- In the same period, Maskelyne and Harrison fight over the proper way to determine longitude
- Maskelyne produces a nautical almanac

1800 - 1900

- 1804-06 Lewis and Clark survey the Louisiana purchase
  - o Making celestial observations at the request of Thomas Jefferson under the tutelage of Ellicott and others using Maskelyne's Almanac

1900 - 2000

- Aircraft
- Satellites
- Nautilus uses inertial navigation to travel to the North Pole under the ice pack
- Sputnik and Transit satellites
- Manned space program
- First orbital explorations of the planets
- GPS
- Cospas-Sarsat

2000 - present

- Asteroids, comets, Mars, and Mercury join the list of solar system objects that have been explored
- Pluto will soon join the list
- It has been demonstrated that X-rays from pulsars can be used for satellite navigation (and for communication)
- The first successful launch of the Orion vehicle has occurred

What are some of the cultural implications of this?

- Maskelyne's 1804 almanac implements the "equation of time"
  - This shows how the speed at which the earth orbits the sun varies in accordance with Kepler's Laws
  - This is reflected in the use, since the mid-1800's, of Greenwich Mean Time to "average-out" the effects of the eccentricity of the earth's orbit with respect to errors between "clock time" and "solar time".
- Supposedly, 26% of American's believe that the sun orbits the earth
  - But, because of the gravitational perturbations of Jupiter, the earth does not orbit the sun; rather, it orbits the barycenter of the solar system.
  - The barycenter is the center of mass of the solar system. (In practice, this is dominated by the mass of the sun and the mass of Jupiter.)
- The impact that facts like this have on day-to-day activities and on sophisticated systems such as GPS will be explained in detail in later modules, and will be investigated in depth in subsequent homework assignments.

Reading

- Begin reading the text.
  - o Chaps. 1 – 5, 7, 9, 10, 12, and 13 are of primary interest.
  - o Read chapters 1 and 2 in preparation for modules 1 and 2.

Assignment 1

- Due: one week after the beginning of term
- Answer the questions in the Word file in the Module 1 Assignments section of Blackboard to the best of your ability with or without consulting reference materials.
- When in doubt, make an intelligent guess. The goal is to stimulate thought and to provide a yardstick against which you can compare your knowledge and way of thinking at the end of the term.
- Reproduce the assignment sheet with space between each question for inserting your answer, and submit the completed .doc or pdf file to the Assignment 1 section on Blackboard.
- The answers will be reviewed during the first “office-hours” session.

End of Mod 1E and of Module 1.