A&AE 565

Guidance and Control of Aerospace Vehicles

1. Instructor: Professor Dominick Andrisani
   Office: Room 328 Grissom
   Office Phone: 494-5135

2. Textbook: Aircraft Control and Simulation, Brian Stevens & Frank Lewis.

3. Seating: Starting next class keep the same seat throughout the semester.

4. Grading policy:
   1/3 of semester grade based on homework and on oral mid term
   1/3 of semester grade based on the team-based course project
   1/3 of semester grade based on the final exam

   I reserve the right to raise or lower your grade by one letter grade based upon my evaluation of your knowledge of the course material formed from my classroom observations.
5. Course prerequisites: A&AE 421, and A&AE 364; (A&AE 564 recommended).
6. Class Attendance is strongly recommended. You are responsible for obtaining notes and homework assignments which take place on days you miss.

Homework #1

Due Wednesday, 1/13/03. Read the Predator information handed out in class. Describe how the Predator aircraft is flown by the remote operator. With this in mind, describe the functions that you think must be implemented in the Predator flight control system. Do a web search for more information about Predator if you need more information.

Outline of the course

Equations of motion: Flat earth, elliptical earth
Flight dynamics

- Pitch dynamics (short period mode, elevator sets angle of attack)
- Phugoid statics dynamics (speed and altitude, front-side and back-side operation)
- Turn statics and dynamics (bank-to-turn, turn coordination)
- Accelerometers

Control Systems Design

- SISO
  - Transfer functions, Root locus (static loop sensitivity),
  - bode plots, Nyquist plots, stability margins
- MIMO
  - State space and relationship to transfer functions
  - Series loop closure design method
- Examples and project
  - Yaw damper, roll command system, heading command,
  - speed command, velocity command

Navigation: Inertial navigation, GPS navigation
Guidance

- Waypoints (longitude, latitude, altitude, speed)
- Angle considerations

Project: Design and simulate a complete Predator B Flight Management system (from waypoint to automatically flown trajectory)

Course Tools

Aircraft Modeling and Simulation Software using Matlab and Simulink
Nonlinear aerodynamic model defined in terms of "constants" > basic constants > "constants" > nonlinear simulation > linearization about trim condition > control system design with linear math models > control system verification in the nonlinear simulation

Control System Design and Simulation
Matlab Control System Design Toolbox: sisotool, rlocus, margin
Simulink for linear and nonlinear dynamical simulation

A&AE 565 Bibliography

Abbott, Ira H. and VonDoenhoff, Albert E, *Theory of Wing Sections Including a Summary of Airfoil Data*, Dover Publications, Inc., 1949, 1959.

Blakelock, John H., *Automatic Control of Aircraft and Missiles*, Second Edition, John Wiley and Sons, Inc., 1991.

Etkin, Bernard, *Dynamics of Atmospheric Flight*, John Wiley and Sons, Inc., 1972.

Etkin, Bernard, *Dynamics of Flight, Stability and Control*, John Wiley and Sons, Inc., 1959, also revised edition in 1981 or 1982.

Hoak, D. E., *USAF Stability and Control DATCOM*, Air Force Flight Dynamics Laboratory, published in nine volumes or sections, Volume 4 is the most useful.

McRuer, Dwane, Ashkenas, Irving and Graham, Dunstan, *Aircraft Dynamics and Automatic Control*, Princeton University Press, 1973.

Miele, Angelo, *Flight Mechanics Volume 1 Theory of Flight Paths*, Addison-Wisley Publishing Company, Inc., 1962.

Perkins, Courtland D. and Hage, Robert E., *Airplane Performance Stability and Control*, John Wiley and Sons, Inc., 1949.

Roskam, Jan, *Airplane Flight Dynamics and Automatic Flight Controls, Part I*, Roskam Aviation and Engineering Corporation, 1979.

Seckel, Edward, *Stability and Control of Airplanes and Helicopters*, Academic Press, 1964.

Smetana, F. O., *Computer Assisted Analysis of Aircraft Performance Stability and Control*, McGraw-Hill Book Company, 1984.

Stevens, B. L. and Lewis, Frank L., *Aircraft Control and Simulation*, John Wiley and Sons, Inc., 1992.

Homework Policy

1. Homework is collected, graded, and returned.
2. NO LATE HOMEWORK IS ACCEPTED.
3. Cooperation on homework can be helpful in learning. Copying someone's homework will not be tolerated.
4. In reading assignments you are responsible for all material whether it is covered in class or not.
5. Homework will be graded by the TA.
6. Homework Format:
   a. Staple multiple pages together.
   b. Every answer must contain physical units. (e.g. feet, seconds, slugs, etc.)
   c. All answers and physical units must be enclosed in a box.
   d. Answers should generally contain three significant digits (i.e. 2.15, $3.24 \times 10^{-4)}$.
   e. Do not hand in a paper pulled from a spiral binder.
   f. Sketches defining coordinate directions, axis system, etc. are almost always required.

NOTES ON NOTE TAKING

1. Date all notes. This indicates the start and end of a lecture for comparison with other notes.
2. Copyeverything written on board.
3. Learn to take notes verbally without waiting for the notes to be written by the professor.
4. Take notes on material not written on the board as well. At least jot down key ideas. Fill in the explanation at home.
5. Review, correct and *copy over* all notes shortly after class. Use the text to help. Any questions which result should be resolved. After this process the copied over notes should contain no errors and you should understand them thoroughly. Notes should be as thorough as a book.

Remarks

Step 5 is important if the class is being taught without a textbook.

My Responsibilities in this Course

1. Facilitate your learning the material of this course.

2. Help you develop into mature, confident, competent, ethical engineers and citizens. This involves material not found in the book or course description.

3. Evaluate your level of skill (assign a grade to your work).

Your responsibilities

1. Learn the material in this course.

2. Conduct yourself in an ethical manner regarding homework and tests and your relationships with colleagues and Purdue University.

3. Achieve the level of skill you are capable of.

4. Learn to speak and write effectively.

5. Survive till tomorrow.

Necessary Student Skills

Note taking from lectures.

Note taking from book.

Time management skills including regular reading, regular homework, and regular review of notes.

Learn to perform well in time restricted situations, e.g., quizzes and tests.