AE 6511 - Syllabus

Optimal Guidance and Control. 3 Credit Hours.

General Information

Description

Euler-Lagrange formulation; Hamilton-Jacobi approach; Pontryagin's minimum principle; Systems with quadratic performance index; Second variation and neighboring extremals; Singular solutions; numerical solution techniques.

Pre- &/or Co-Requisites

AE 3515

Course Goals and Learning Outcomes

This course is indented as an introduction to the elements of Optimal Control theory and Calculus of Variations. Although the main emphasis will be on applications from aerospace engineering, several examples will be provided on the use of optimal control to other disciplines such as, economics, mechanical systems, human behavior, etc.

Upon successful completion of this course, you should be able to:

- Test the necessary and sufficient conditions for a local and a global minimizer of a functions with several arguments for both constrained and unconstrained optimization problems
- Formulate and solve a problem in the space of functions
- Find the optimal control function that will optimize a given performance index subject to dynamic system constraints
- Solve analytically problems with quadratic costs and linear dynamics (LQR)
- Get acquainted with basic elements of game theory

Course Requirements & Grading

Note: Graded components of a course may vary with each offering. The example below is typical but subject to change.

Description of Graded Components

Final Grade = Homework x 20% + Mid-Term x 35% + Final Exam/Project x 45%

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	85-100%
B	70-84%
C	51-69%
D	46-50%
F	0-45%

Topics Covered

Note: The exact topics covered in a course may vary with each offering. The example below is typical but subject to change.

- Finite-dimensional optimization problems; minima and maxima of functions
- Variational cones; Gateaux and Frechet derivatives
- Necessary and sufficient conditions
- Existence and uniqueness conditions; Weirstrass theorem
- Minima and maxima subject to constraints
- Lagrange multipliers; Kuhn-Tucker conditions
- Infinite-dimensional optimization problems; minima and maxima of functionals
- Elements of calculus of variations
- Lagrange-Euler necessary conditions
- Legendre and Jacobi conditions; conjugate points; Erdmann corner conditions
- Optimal control problems with control constraints
- Pontryagin Maximum Principle
- Legendre-Clebsch condition; bang-bang control
- Optimal control problems with state and control constraints
- Singular optimal control
- Optimal feedback control
- Dynamic programming and Hamilton-Jacobi theory
- The Linear quadratic control problem; the Riccati equation
- Neighboring optimal guidance
- Elements of differential games; pursuit-evasion games; H-infinity control

Course Materials

Note: Course materials may vary with each offering. The example below is typical but subject to change.

Textbook

There is no required textbook. A clear, detailed set of lecture notes should be enough. Selected chapters from the book A Course in Classical Optimal Control by D. Bernstein and P. Tsiotras (in preparation) will be provided and will be used extensively during the semester. As an additional resource, the students can use the book Optimal Control Theory with Aerospace Applications by J. Ben-Asher, AIAA Publishing, 2010 or Applied Optimal Control, by A. E. Bryson, Jr. and Y.-C. Ho, Hemisphere Publishing Corporation, New York, 1975.

Course notes

A detailed set of notes will be distributed via Canvas.