Texas A&M University
Departmental Request for a New Course
Undergraduate • Graduate • Professional
- Submit original form and attach a course syllabus.

Aerospace Engineering

1. This request is submitted by the Department of

2. Course prefix, number and complete title of course: AERO 631- Advanced Trajectory Optimization for Aerospace Systems

3. Course description (not to exceed 50 words):
   Numerical solution of optimal control problems (OCP) as a nonlinear programming problem (NLP); control of a nonlinear missile using SNOPT, trajectory generation, motion planning, atmospheric entry problems, elements of approximation, distributed and parallel computation techniques, dynamical systems, stability theory, parameter optimization.

4. Prerequisite(s):
   Graduate classification; some knowledge of optimal control theory expected.

5. Is this a variable credit course? □ Yes □ No
   If yes, from _________ to _________.

6. Is this a repeatable course? □ Yes □ No
   If yes, this course may be taken ________ times.
   Will this course be repeated within the same semester? □ Yes □ No

7. Has this course been taught as a 489/689? □ Yes □ No
   If yes, how many times? __________
   Indicate the number of students enrolled for each academic period it was taught: 5-08C, 6-07C

8. This course will be:
   a. required for students enrolled in the following degree program(s) (e.g., B.A. in history)
   b. an elective for students enrolled in the following degree program(s) (e.g., M.S., Ph.D. in geography)
   MEN, MS, PHD in aerospace engineering or related programs

9. If other departments are teaching or are responsible for related subject matter, the course must be coordinated with these departments.
   Attach approval letters.

10. Approval recommended by:
    Head of Department □ Date
    Head of Department (if cross-listed course) □ Date
    Submitted to Coordinating Board by:
    Associate Director, Curricular Services □ Date

Questions regarding this form should be directed to Sandra Williams at 845-8201.
Curricular Services – 11/07

N.K. Anand

Attachment B1
SYLLABUS

AEROSPACE ENGINEERING
AERO 631 ADVANCED TRAJECTORY OPTIMIZATION FOR AEROSPACE SYSTEMS

Semester: TBA
Day/Time/Place: TBA

Course Description and Prerequisites

This course will cover numerical solution of optimal control problems (OCP) as a nonlinear programming problem (NLP) with applications including control of a nonlinear missile, trajectory generation for differentially flat UAVs, motion planning with simple obstacles, atmospheric entry problems for crew return vehicles. The nonlinear programming problem will be solved using the student version of SNOPT. Students will be introduced to elements of approximation theory, numerical analysis, stochastic optimal control theory, dynamical systems and stability theory and advanced parameter optimization methods. Projects will be assigned individually and a term paper is expected at the end of the semester.

Prior knowledge of aircraft flight mechanics or spacecraft dynamics is not necessary. Graduate classification and a background in optimal control theory are necessary. 

Learning Outcomes

(i) Understand and derive numerical solution techniques to solve linear and nonlinear optimal control problems.
(ii) Learn advanced techniques to approximate nonlinear systems using differential flatness to reduce computational complexity.
(iii) Understand elements of approximation theory to transcribe optimal control problems to nonlinear programming problems including direct collocation, pseudo-spectral methods, Spline approximations, meshless FEM approaches.
(iv) Solve stochastic optimal control problems using polynomial chaos theory.
(v) Learn to apply receding horizon control techniques to engineering problems.

Instructor Information

Name: Dr. R. Bhattacharya, Assistant Professor, Department of Aerospace Engineering
Telephone number: (979) 862-2914
Email address: raktim@aero.tamu.edu
Office hours: By Appointment
Office location: 727C HRBB
TA name:

Textbook and/or Resource Materials

No textbook. Material will be provided in form of handouts. Following references will used.

References:
1. Practical Guide to Splines, Carl de Boor.
2. Orthogonal Polynomials, G. Szego.
3. Parallel and Distributed Computation: Dimitri P. Bertsekas and John N. Tsitsiklis
4. Applied Optimal Control by A.E. Bryson and Y.-C. Ho
5. Dynamic Optimization by A. E. Bryson, Jr.
6. IEEE Transactions in Automatic Control
7. Automatica, A Journal of IFAC, the International Federation of Automatic Control
8. Journal of Guidance, Control, and Dynamics
### Grading Policies

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework</td>
<td>25%</td>
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<tr>
<td>Midterm Exam</td>
<td>25%</td>
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<tr>
<td>Final Project</td>
<td>50%</td>
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More information on the grading policy can be found at: [http://student-rules.tamu.edu](http://student-rules.tamu.edu)

### Course Topics, Calendar of Activities, Assignments, Test Dates

<table>
<thead>
<tr>
<th>TOPICS</th>
<th>HOURS</th>
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<tbody>
<tr>
<td><strong>1. Introduction</strong>&lt;br&gt;a. Optimal control problem formulation&lt;br&gt;b. Euler-Lagrange formulation&lt;br&gt;c. Hamilton Jacobi Bellman equations</td>
<td>3</td>
</tr>
<tr>
<td><strong>2. Elements of Nonlinear Dynamical Systems</strong>&lt;br&gt;a. Feedback linearization&lt;br&gt;b. Differential flatness&lt;br&gt;c. Inverse optimality</td>
<td>6</td>
</tr>
<tr>
<td><strong>5. Stochastic Optimal Control</strong>&lt;br&gt;a. Introduction to Polynomial Chaos&lt;br&gt;b. Transcription of stochastic optimal control to deterministic optimal control using polynomial chaos</td>
<td>6</td>
</tr>
<tr>
<td><strong>6. Applications</strong>&lt;br&gt;a. Receding horizon control of dynamical systems&lt;br&gt;b. Real-time trajectory generation for UAVs&lt;br&gt;c. Atmospheric reentry problems</td>
<td>6</td>
</tr>
</tbody>
</table>

Total = 42

### Other Pertinent Course Information

**Attendance Policy:** Students are expected to attend class.

**Copyrights**
The handouts used in this course are copyrighted. By "handouts" we mean all materials generated for this class, which include but are not limited to syllabi, lab problems, in-class materials, review sheets, and additional problem sets. Because these materials are copyrighted, you do not have the right to copy the handouts, unless the author expressly grants permission.

**Americans with Disabilities Act (ADA) Policy Statement**
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodations of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services, in Cain Hall, Room B118, or call 845-1637. For additional information visit [http://disability.tamu.edu](http://disability.tamu.edu)

**Academic Integrity Statement and Policy**
For additional information, please visit: [http://www.tamu.edu/aggiehonor](http://www.tamu.edu/aggiehonor)

"An Aggie does not lie, cheat, or steal, or tolerate those who do."

3 of 3 B1