MAE 561, Wing Theory
Spring 2010
Course Outline

Instructor
Dr. Ashok Gopalarathnam
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http://www.mae.ncsu.edu/directories/faculty/gopal.html
2404 Broughton Hall
(919) 515-5669
Office hours: 3:00pm–4:00pm Mondays and Wednesdays
Other times by appointment

Schedule
Recorded lectures from Spring 2006 will be posted online by Engineering Online
No live lectures
For on-campus students only, instructor will hold “Meet the class” sessions at convenient
times approximately once a month as arranged by email
The recorded lectures may be posted incrementally (not all together). Likewise, either or
both the course websites may be updated incrementally during the semester.
Course schedule is appended to the end of this course outline
Use this course schedule for viewing lectures and completing assignments
Course website for lecture videos and instructor’s scanned notes is:
http://engineeringonline.ncsu.edu/onlinecourses/coursehomepages/SPR2010/MAE561.html
Course website for additional material, home works, assignments, and projects is:
http://courses.ncsu.edu/mae561

Topics
- Introduction to airfoil aerodynamics
- Lifting line theory
- Weissinger’s method for nonplanar, swept and multiple wings
- Effect of taper, twist, sweep on lift, induced drag, and stall characteristics
- Munk’s theories
- Overview of vortex-lattice and panel methods
- Methods for inverse aerodynamic design and optimization of wings
- Design of winglets and non-planar wings
- Issues involved in tailless, aft-tail, and canard-configured aircraft
  Multidisciplinary considerations: connections to stability & control and structures
- Rotating wings: propellers, helicopters, wind-turbine rotors
  Actuator disk and blade-element momentum theories
- Introduction to high-speed wing theory
Suggested books (not required)


John D. Anderson, “Fundamentals of Aerodynamics,” 3rd Edition, McGraw Hill. (Textbook for MAE 355 *Aerodynamics I* — highly recommended if you do not have a background in Aerospace Engineering. Earlier editions or other similar textbooks will also work.)

Other supplemental material will be provided by the instructor.

Assignments, Grading, Projects, Attendance, etc.

- Homeworks. (25%)
- Programming assignments. Can be done in either Fortran, C, C++, or Matlab (35%)
- One take-home final examination. (20%)
- An individual research project with 20-min presentation (only for on-campus students) and term paper. Topics to be identified by each student, based on individual research interests. (20%)
  For logistical reasons, distance-ed students need not make live presentations, but each needs to submit a term paper and presentation slides. Their project grades will be determined based on the paper and slides.
  On-campus students need to submit term paper, presentation slides, and will also have to make live presentations. Attendance for on-campus students compulsory on all presentation days.
- All homeworks and projects will need to be submitted electronically via Wolfware (http://courses.ncsu.edu/mae561). They can be scanned-in versions of hand-written pages. Pdf files are preferred for the submissions.
- Grading will be determined using a curve with the following general guideline:
  95+ – A+
  90–94 – A
  85–89 – A-
  80–84 – B+
  75–79 – B
  70–74 – B-
  65–69 – C+
  60–64 – C
  55–59 – C-
<table>
<thead>
<tr>
<th>Week #</th>
<th>Week of</th>
<th>Lectures to watch (lecture numbers shown)</th>
<th>Assignments</th>
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<tbody>
<tr>
<td>1</td>
<td>January 10</td>
<td>1. Course motivation&lt;br&gt;2. Airfoil aerodynamics review</td>
<td>• Brush up programming skills</td>
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<td>2</td>
<td>January 17</td>
<td>3. Airfoils review continued&lt;br&gt;4. Finite wing flows&lt;br&gt;Biot-Savart law</td>
<td>• Brush up programming skills&lt;br&gt;• Start HW 1 – includes one small programming&lt;br&gt; problem based on&lt;br&gt; Lecs. 4 &amp; 5</td>
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<td>3</td>
<td>January 24</td>
<td>5. Biot-Savart law continued&lt;br&gt;6. Lifting line theory (LLT)</td>
<td>• Work on HW 1&lt;br&gt;• Develop ideas for research project topic (to be worked on during entire term)</td>
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<td>4</td>
<td>January 31</td>
<td>7. LLT continued&lt;br&gt;8. LLT and numerical implementation</td>
<td>• Work on HW 1</td>
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<td>5</td>
<td>February 7</td>
<td>9. LLT program structure&lt;br&gt;10. Basic &amp; Additional load distributions</td>
<td>• HW 1 due 8 February&lt;br&gt;• Start Prog. Assign 1 (discussed in early part of lecture 12)</td>
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<td>6</td>
<td>February 14</td>
<td>11. Schrenk’s method, stall characteristics&lt;br&gt;12. Prog. Assign. 1 discussion&lt;br&gt;Wing contribution to longitudinal stability &amp; control</td>
<td>• Work on PA 1&lt;br&gt;• Work on research project idea</td>
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<td>7</td>
<td>February 21</td>
<td>13. Prog. Assign. 1 discussion&lt;br&gt;Tailless airplanes&lt;br&gt;14. Discussion of 1-page proposal for research project&lt;br&gt;McCormick’s model for low AR wings</td>
<td>• One-page proposal due on February 26 for research project&lt;br&gt;(discussed in early part of Lec. 14)&lt;br&gt;• Work on PA 1&lt;br&gt;• Start HW 2 if done with PA 1</td>
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<tr>
<td>Week</td>
<td>Date</td>
<td>Event</td>
<td>Assignments</td>
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| 8    | February 28 | 15. HW 2 discussion  
Intro to Weissinger’s method  
16. Weissinger’s method & numerical implementation | • Prog. Assign 1 due 29 Feb  
• Work on HW 2 – problems based on your LLT code |
| 9    | March 7  | 17. Weissinger method numerical implementation continued  
18. Weissinger method numerical implementation continued | • HW 2 due March 10  
• Start Prog. Assign 2 – Weissinger method |
| 10   | March 14 | Spring break                                                        |                                                                                  |
| 11   | March 21 | 19. Far-field analysis  
20. Far-field analysis, Trefftz plane, Munk’s theorems | • Work on PA 2  
• Work on research project |
| 12   | March 28 | 21. Munk’s theorems continued  
Thursday and Friday – Spring holiday | • Work on PA 2  
• Work on research project |
| 13   | April 4  | 22. R.T.Jones’s minimum drag solutions  
23. Minimum drag solutions continued | • Complete code for your PA 2  
• Start HW 3 – problems using your Weissinger code |
| 14   | April 11 | 24. Winglets and tip extensions  
25. Start propeller aerodynamics | • PA 2 and HW 3 due April 16 |
| 15   | April 18 | 26. Propellers continued  
Swept wings – overview  
27. Discussion of adaptive wings | • Work on research project (paper and slides) |
| 16   | April 25 | 28. Recording of on-campus student presentations from 2006 – can skip this lecture (optional)  
Dead week | • Research project (paper and slides) due Apr 26  
• Presentations to be scheduled for on-campus students  
• Finals handed out 30 April |
| 17   | May 2    | Reading days and finals                                            | • Finals due 7 May |

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