AE 323 – APPLIED AEROSPACE STRUCTURES
Spring 2023

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Class Hours: Monday, Wednesday, Friday 9:00 am–9:50 am, 106B8 ENGH

Teaching Assistants: Mr. Nikhil Ashok
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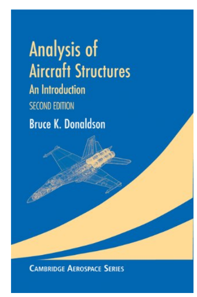
Office Hours: **JL:** Monday, Wednesday 11:00 am–12:00 pm, 306B Talbot Lab
NA: Tuesday, Thursday 2:00 pm–5:00 pm, Location: 319N TLB

Course Website: UIUC Canvas: https://canvas.illinois.edu/courses/49642
Homework problems and solutions, the powerpoint slides used in class, and sample exams and solutions will be posted here. Homeworks will also be uploaded here.

Recommended Textbook: Analysis of Aircraft Structures
Bruce K. Donaldson, Cambridge University Press, 2008, 2012
Print ISBN: 978-0-521-86583-8
Available online via UIUC Library via Cambridge Core (UIUC IP)
(There is also a 1993 edition from McGraw-Hill)



Exams: Two 50-minute midterm in-class exams (tentatively scheduled during weeks 8 and 13) and a final exam (8-11am, Monday Dec. 16) will be held. All exams will be **closed book and closed notes** and the material covered in each exam is **cumulative** from the beginning of the semester. An equation sheet will be provided in each exam.

Homework: Graded homework will be assigned roughly once a week, although the exact pacing will follow in class lecture progress. Completed homework will be submitted online through Canvas. Although the homework does contribute to the overall grade (see below), the homework exercises should mainly be viewed as a learning tool to help you understand the material. It is impossible to master the material in the course without being in a position to solve a large proportion of these problems. In that sense, your success in the course will depend highly upon your completing these exercises. Your chances of success in the exams will increase drastically if you do the homework on a regular basis. If you feel you need additional practice beyond the exercises handed out, you should try to solve additional problems that can be found in various textbooks. Solutions to the exercises will be posted on the course website after the homework is handed in. These solutions are also a learning tool and you should refer to them after having attempted the relevant exercises.

Grading:

	Homework:	15%
	Midterm exam #1: (**tentatively** on Friday October 18, 2024)	25%
	Midterm exam #2: (**tentatively** on Wednesday November 20, 2024)	25%
	Final exam: (8am-11am, Monday December 16, 2024)	35%

Final grades will be allocated using the above percentages. A plus/minus scale will be used, although there is no grade curving.

Objectives: This course is designed to introduce students to the fundamental concepts of engineering theory of bending, torsion and extension of aircraft structures and to allow students to solve Boundary Value Problems of such structures subjected to a variety of boundary conditions. The specific objectives of this course are for the students to:

(a) be able to solve for stress, strain and displacement fields in beam bending problems,
(b) be able to solve thick and thin walled, single and multi-cell torsion problems,
(c) obtain an introduction into the field of aeroelasticity,
(d) understand the use of energy methods and their equivalence with equilibrium methods,
(e) become familiar with elastic column instability (buckling) problems.

AE323–TABLE OF CONTENTS

0. INTRODUCTION

1. FUNDAMENTAL CONCEPTS OF ELASTICITY

1.1. Stresses
1.1.1. Definition of traction and stress
1.1.2. Equations of equilibrium
1.1.3. Principal stresses and directions
1.2. Strains
1.2.1. Normal and shear strains
1.2.2. Compatibility
1.3. Material response
1.3.1. Uniaxial material behavior
1.3.2. Generalized Hooke's law

2. STRENGTH OF MATERIALS ANALYSIS OF STRAIGHT, LONG BEAMS

2.1. Beam bending/extension
2.1.1. Bending moment and Shear force diagrams
Boundary conditions
Conventions for internal forces and moments
Definitions of resultant forces and moments
2.1.2. Bending and extensional stresses
Basic assumptions of Euler-Bernoulli beam theory
Displacements and strains in the beam
Bending and extensional stresses
Accuracy of beam stress equation
2.1.3. Beam deflections in bending/extension
Equilibrium in terms of force and moment resultants
Equilibrium in terms of deflections
Boundary conditions
2.1.4. Elastic boundary conditions
2.1.5. Partial span and concentrated loads
Dirac delta function
Step function
2.1.6. Comparison with 2D and 3D solutions

2. STRENGTH OF MATERIALS ANALYSIS OF STRAIGHT, LONG BEAMS (cont.)

2.2. Beam torsion

2.2.1. St Venant's theory of beam torsion
- Introduction
- St. Venant's displacement solution

2.2.2. Prandtl's solution of beam torsion
- Prandtl's stress solution
- Membrane analogy

2.2.3. Approximate solutions for torsion of thin-walled structures
- Introduction
- Open cross-section beams
- Closed cross-section beams
- Torsion of beams with variable cross-sections

2.2.4. Shear center

2.2.5. A brief incursion into aeroelasticity

3. ENERGY METHODS

3.1. Work and potential energy principles

3.1.1. Introduction

3.1.2. Work and potential energy

3.1.3. Virtual work and virtual potential energy

3.1.4. Variational operator

3.1.5. Principle of virtual work (PVW)
- PVW for a rigid system
- PVW for a deformable body
- PVW for conservative systems

3.1.6. Complementary virtual work

3.2. Analytical solutions of static problems using energy methods

3.2.1. Introduction

3.2.2. Computation of strain energy and complementary strain energy

3.2.3. Castigliano's theorems: Derivation
- Application to statically determinate structures
- Application to statically indeterminate structures

3.2.4. Approximate solutions: Rayleigh-Ritz method

4. INTRODUCTION TO BUCKLING

4.1. Introduction
4.2. Beam buckling using Euler-Bernoulli theory
4.3. Beam buckling using energy methods