



**FACULTY OF ENGINEERING**  
**SCHOOL OF MECHANICAL AND MANUFACTURING ENGINEERING**

**AERO3410**

# **AEROSPACE STRUCTURES**

**SESSION 1, 2009**

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## **COURSE STAFF**

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Consultation concerning this course is available during the tutorial and computer laboratory class. The lecturer can be contacted at other times by email or a time for consultation can be arranged by telephone.

## **COURSE DETAILS**

UOC6 HPW6 WKS12 S1  
 Prerequisites: MMAN2400

### **Units of credit**

This is a 6 Unit-of-Credit (UoC) course, and involves 6 hours per week (h/w) of face-to-face contact.

UNSW expects that you will put in, on average, 45 h/w for 24 UoC (including both in-class and out-of-class time) for an effective 14 weeks of the session (twelve weeks plus stuvac plus one effective exam week) for an average student aiming for a credit grade. Various factors, such as your own ability, your target grade, etc., will influence

the time needed in your case. Some students spend much more than 45 h/w, but you should aim for not less than 45 h/w on coursework for 24 UoC.

This means that you should aim to spend not less than 11 h/w on this course, i.e. an additional 5 h/w of your own time. This should be spent in making sure that you understand the lecture material, completing the set assignments, and further reading about the course material.

### **Parallel teaching**

There is no parallel teaching in this course.

### **COURSE AIMS**

The objective of this course is to develop an understanding of the configuration and materials used in the airframe, the ability to analyse aerospace structures using classical analysis techniques, and skills to implement modern computational analysis techniques such as the finite element method.

The first part of the course starts with lectures on the configuration of the aircraft, loads on the airframe and materials used. The lectures then deal with bending, shear, torsion and deflection of open and closed thin-walled beams and multi-cell structures. The methods developed are applied to the analysis of the fuselage, fuselage frames, wings and wing ribs. This segment gives the student the capability to analyse simple airframe structures and develops an intuitive understanding of why aircraft structures have evolved into the current configurations. The remainder of this part of the course contains lectures on composite panels to introduce the material properties of carbon fibre and develop methods for analysis of laminates. Methods will be developed to apply the classical analysis procedures to composite structures.

The second part of the course starts with virtual work and energy methods and lays a theoretical foundation for the finite element method. This part then introduces buckling of columns, plates and stiffened panels. Buckling is a significant feature of the response of thin walled stiffened panels under compression. The course will differentiate between local buckling and the final crippling and collapse of the structure. A short introduction to the vibration of beams is also given.

One hour per week will be spent in a computer laboratory developing skills to implement a commercial finite element system. Finite elements form the basis of modern structural analysis but cannot be implemented successfully without an understanding of the classical methods of analysis that are discussed in the other parts of the course.

### **How the course relates to other course offerings and overall program(s) in the discipline**

The course is the first of two courses on aerospace structures. This course focuses on classical analysis techniques and extends the work in MMAN2400. The finite element method is introduced. The second course on aerospace structures, AERO4410 Advanced Aerospace Structures and Vibrations, deals with the practical application of

the finite element method to aerospace structures and considers the analysis of a satellite structure for vibration response and the analysis of a typical aircraft structural component for strength and stiffness. It revises the conceptual design and layout of the aircraft structure, treats the airframe as a flexible structure by considering aeroelasticity, deals with detailed stressing of the airframe and the aging processes of fatigue and environmental degradation of composites and metals.

## **STUDENT LEARNING OUTCOMES**

By the end of this course it is expected that the student will understand:

- the layout of aircraft structures and the role played by different components;
- methods of analysing simple trusses and frames and identification of load paths in the structure;
- methods for determining stress and deflections of thin walled single and multi-celled stiffened structures for axial loads, bending and shear;
- application of these techniques to the analysis of wing and fuselage structures in aircraft;
- the analysis of buckling of thin walled structures under compression, bending and shear and be able to determine the collapse load of structures under compression loads;
- be able to analyse simple structures manufactured from composite materials and determine laminate stress and strain;
- be able to implement a commercial finite element program for the linear static and dynamic analysis of aircraft structures.

## **THE RATIONALE BEHIND THE APPROACH TO LEARNING AND TEACHING**

Analytical concepts such as the analysis of aircraft structures are best learnt by practice on worked examples. The course texts have numerous worked examples and students are encouraged to participate in continuous assessment by submitting a solution to a tutorial problem each week.

The lectures are divided into two streams to reduce the pace at which material is covered in each "Part" and to enable background material for the finite element method to be presented in parallel with a session each week in the computer laboratory. This allows the skills in implementing the finite element method to be developed over the full session.

Time will be set-aside during tutorials for discussion of the practical application of the techniques being taught. It is expected that tutorials will be marked and handed back in the week following submission. You will have feedback and discussion while the topic is fresh in your mind to improve the learning experience.

## **TEACHING STRATEGIES**

The text by Megson will be closely followed. You are strongly encouraged to purchase the text by Megson as it will be a valuable reference during your career as an aerospace engineer. Notes on the finite element method and composite materials will be available through WebCT.

A hand-in tutorial will be given out each week to be handed in at the tutorial two weeks later. This should be supplemented by reading from the course text and retrieval of related information from the internet.

The development of the skills for implementing the finite element method will be based on hands-on sessions in the computer laboratory. Students will be expected to work individually through a set of examples that give direct instruction on each step that needs to be taken before attempting an assignment that will be assessed. Individual skills will be checked by a tutor at the end of the course.

## **ASSESSMENT**

A tutorial problem will be handed out each week to be handed in at the tutorial two weeks later (Total of 10 tutorials).

An assignment will be handed out for the finite element component in Week 7 to be submitted at the computer laboratory class in Week 10. During weeks 11 and 12 an on-screen check will be made of your competency with FEA modeling. Your assignment mark will not be included in your course assessment unless you can demonstrate competency in working with the FEA packages.

There will be a mid-session test during the Thursday class in Week 6.

A final written examination in the examination period will be closed book.

Passing the Course:-

Path A:- 40% final written examination, 20% mid-session test, 20% tutorials, 20% FEA assignment and competency check..

Path B:- 80% final examination 20% FEA assignment and competency check.

The mark for Path A and the mark for Path B will both be calculated and the higher of the two marks will be awarded for the subject.

In order to pass the course, you must achieve an overall mark of at least 50%.

### **Late submission**

Tutorial problems and the FEA assignment must be handed in to the tutor at the time indicated. Late submissions cannot be accepted.

## **ACADEMIC HONESTY AND PLAGIARISM**

### **What is Plagiarism?**

Plagiarism is the presentation of the thoughts or work of another as one's own.\*

Examples include:

- direct duplication of the thoughts or work of another, including by copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement;
- paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- piecing together sections of the work of others into a new whole;

- presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and
- claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†

For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.

Knowingly permitting your work to be copied by another student may also be considered to be plagiarism.

Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does *not* amount to plagiarism.

The Learning Centre website is main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located via:

[www.lc.unsw.edu.au/plagiarism](http://www.lc.unsw.edu.au/plagiarism)

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.

Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

\* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle

† Adapted with kind permission from the University of Melbourne.

Further information on School policy and procedures in the event of plagiarism is presented in a School handout, *Administrative Matters for All Courses*, available from the School office separately or as part of *The Guide*.

## COURSE SCHEDULE

All lectures are given by the course convenor

### TEACHING SCHEDULE 2009 BY TOPIC

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#### Wednesday 0900-1100 Part A

Week 1	Introduction, basic airframe layout, loads on the airframe, materials of airframe construction, load paths.
Week 2	Bending and shear of open and closed thin-walled beams.
Week 3	Torsion of open and closed thin-walled beams.
Week 4	Deflection of thin walled beams, tapered beams.
Week 5	Fuselage structures
Week 6	Multi-cell structures – wings
Week 7	Fuselage frames and wing ribs.
Week 8	Cut-outs in wings and fuselage, structural constraint – shear lag.
Week 9	Introduction to fibre reinforced materials.
Week 10	Properties of uni-directional laminates.
Week 11	Multi-ply laminates A
Week 12	Multi-ply laminates B, failure

#### Thursday 1400-1600 Part B

Week 1	Virtual work and energy – the unit load method, plane frames and space structures.
Week 2	The finite element solution process.
Week 3	The element library.
Week 4	Loads and boundary conditions, two-dimensional analysis.
Week 5	Linear static and dynamic analysis of aerospace structures.
Week 6	Mid-Session Test
Week 7	Thin plate theory, buckling of simple columns and plates.
Week 8	Combined loads, buckling of stiffened panels.
Week 9	Crippling and collapse.
Week 10	Dynamic analysis of spring-mass systems.
Week 11	Vibration of simple beams.
Week 12	Revision

#### Wednesday 1100-1200 Tutorial Odd Weeks Part B, Even Weeks Part A

Thursday 1600-1800 FEA Application Computer Laboratory Room 206. The class will be divided into two groups. On odd weeks Group A 1600-1700, Group B 1700-1800. On even weeks Group B 1600-1700, Group A 1700-1800.

## TEACHING SCHEDULE 2009 RESOURCES

### Wednesday 0900-1100 Part A

Week	Date	Topic	Resource
1	11/03	Introduction, basic airframe layout, loads on the airframe, materials of airframe construction, load paths.	Meg Ch11-14
2	18/3	Bending and shear of open and closed thin-walled beams.	Meg Ch16-17
3	25/3	Torsion of open and closed thin-walled beams, structural idealisation.	Meg Ch18-20
4	01/4	Deflection of thin walled beams, tapered beams.	Meg Ch16,20,21
5	08/4	Fuselage structures	Meg Ch22
6	22/4	Multi-cell structures – wings	Meg Ch23
7	29/4	Fuselage frames and wing ribs.	Meg Ch24
8	06/05	Cut-outs in wings and fuselage, structural constraint – shear lag.	Meg Ch22,23,26,27
9	13/05	Introduction to fibre reinforced materials.	Meg CH25
10	20/05	Properties of uni-directional laminates.	Handout
11	27/05	Multi-ply laminates A	Handout
12	03/06	Multi-ply laminates B, failure	Handout

### Thursday 1400-1600 Part B

Week	Date	Topic	Resource
1	12/03	Virtual work and energy – the unit load method, plane frames and space structures.	Meg Ch4-5
2	19/3	The finite element solution process.	Handout & Meg Ch6
3	26/4	The element library.	Handout
4	02/4	Loads and boundary conditions, two-dimensional analysis.	Handout
5	09/4	Linear static and dynamic analysis of aerospace structures.	Handout
6	23/4	Mid-Session Test	
7	30/4	Thin plate theory, buckling of simple columns and plates.	Meg Ch7-9
8	07/05	Combined loads, buckling of stiffened panels.	Meg Ch9 & Handout
9	14/05	Crippling and collapse.	Meg Ch9 & Handout
10	21/05	Dynamic analysis of spring-mass systems.	Handout
11	28/05	Vibration of simple beams.	Handout
12	04/06	Revision	

## Wednesday 1600-1700 Tutorial

Tutorials	Odd Weeks Part B	Selection of problems from handouts and Megson
	Even Weeks Part A	

## Thursday 1600-1700 or 1700-1800 FEA Computer Laboratory Room 206.

Week	Date	Topic	Resource
1	12/03	Introduction to MD.Patran and MD.Nastran	On-line help
2	19/3	Hands-on calculation 1 (2D Analysis)	Handout
3	26/4	Hands-on calculation 2 (3D Analysis)	Handout
4	02/4	Hands-on calculation 3 (Space Frame)	Handout
5	09/4	Hands-on calculation 4 (Box Structure)	Handout
6	23/4	FEA for Stress Concentration	On-line help
7	30/4	FEA for Stress Concentration	On-line help
8	07/05	FEA for Vibration Analysis	On-line help
9	14/05	FEA for a Typical Airframe Component	Handout
10	21/05	FEA for a Typical Airframe Component	Handout
11	28/05	Introduction to ANSYS	On-line help
12	04/06	Introduction to ANSYS	On-line help

## RESOURCES FOR STUDENTS

### TEXTBOOK

Megson, T.H.G. Aircraft Structures for Engineering Students  
Fourth Edition. Elsevier 2007.

### References:

Daniel, I.M. and Ishai, O. Engineering Mechanics of Composite Materials. Oxford University Press. 1994  
Niu, M.C.Y.<sup>a</sup> Airframe Structural Design, Conmilit Press 1988  
Niu, M.C.Y.<sup>b</sup> Composite Airframe Structures, Conmilit Press 1992  
Flabel, J.C. Practical Stress Analysis for Design Engineers, Lake City Publishing Company 1997.  
Baker A., Dutton S. and Kelly, D. Composite Materials for Aircraft Structures 2<sup>nd</sup> Edition. AIAA Education Series (2004)

## Additional materials provided in WebCT

This course has a website on WebCT Vista. It includes:

- Notes and materials distributed by the lecturer;
- Record of marks for continuous assessment;

- Copies of tutorials (as they are issued, in case you missed the hand-out in class).

### **Recommended Internet sites**

There are many websites giving lectures, papers and data. These websites will be identified in the lectures.

### **Other Resources**

- If you wish to explore any of the lecture topics in more depth, then other resources are available and assistance may be obtained from the UNSW Library. One starting point for assistance is:

[info.library.unsw.edu.au/web/services/services.html](http://info.library.unsw.edu.au/web/services/services.html)

## **COURSE EVALUATION AND DEVELOPMENT**

Your feedback on the course is gathered periodically, and this feedback is considered carefully with a view to acting on it constructively wherever possible.

Feedback is gathered using various means, including the Course and Teaching Evaluation and Improvement (CATEI) process, informal discussion in the tutorial class for the course, and the School's Student/Staff meetings.

## **ADMINISTRATIVE MATTERS**

Information about each of the following matters is presented in a School handout, *Administrative Matters for All Courses*, available from the School office separately or as part of *The Guide*. It is essential that you obtain a copy, read it carefully and become familiar with the information, as it applies to this course and to each of the other courses in which you are enrolled.

- Expectations of students (including attendance at lectures and tutorials/laboratory classes/seminars; and computer use, for example, in the use of email and online discussion forums).
- Procedures for submission of assignments and the School's policy concerning late submission.
- Information on relevant Occupational Health and Safety policies and expectations:  
[http://www.hr.unsw.edu.au/ohswc/ohs/ohs\\_home.html](http://www.hr.unsw.edu.au/ohswc/ohs/ohs_home.html)
- Examination procedures and advice concerning illness or misadventure.

### **Equity and diversity**

Students who have a disability which requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course

convenor prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Student Equity and Disabilities Unit (SEADU) located on the Ground Floor of the Goodsell building (F20). Phone 9385 4734, email [seadu@unsw.edu.au](mailto:seadu@unsw.edu.au) or via the website [www.studentequity.unsw.edu.au](http://www.studentequity.unsw.edu.au).

Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

Prof D. Kelly  
February 2009