Aeroelasticity

Academic Year: (2017 / 2018) **Review date: 19/09/2014 16:41:18**

Department assigned to the subject: Bioengineering and Aeroespace Engineering Department

Coordinating teacher: CLIMENT MAÑEZ, HECTOR

Type: Compulsory ECTS Credits : 3.0

Year : 4 Semester : 1

DESCRIPTION OF CONTENTS: PROGRAMME

Aeroelasticity & Dynamic Loads. Getting Started.

- Aeroelasticity as a multidisciplinary task
- Normal modes at a glance
- Stability problems vs. Response problems
- Basic flutter mechanisms. CS25.629

2D Aeroelasticity: fixing concepts with some analytical 2D solutions

- The ¾ span aerofoil. Pitch and plunge modes.
- Revisiting steady aerodynamics. The standard atmosphere.
- Introduction to 2D unsteady aerodynamics. Wagner, Küssner, Theodorsen.
- Solution of the 2D aeroelastic equation.
- Sensitivity to Xcg.

2D & 3D Static aeroelasticity: divergence and control reversal

- Static aeroelasticity of a 2D rigid aerofoil.
- Static aeroelasticity of a fixed wing
- Divergence. Effect of sweep angle on divergence speed.
- Control effectiveness. Effect of wing flexibility on control effectiveness.

3D Aeroelasticity: The structural model & the normal modes

- Revisiting 1 d.o.f system.
- Multiple d.o.f. systems

- The Finite Element Method (FEM) for structural analysis.
- From stick models to full FEM models. The stiffness matrix.
- Mass models. The mass matrix.
- Condensation.
- Structural Normal modes. Frequencies and mode shapes.

The experimental modal analysis and the GVT. Dynamic model validation.

- Ground Vibration Test (GVT) description.
- Introduction to Digital Signal Processing (DSP). The Fast Fourier Transform (FFT).
- Experimental Modal Analysis.
- Comparison between test and simulations. MAC.
- Updating FEM model to match GVT results.

3D Aeroelasticity: unsteady aerodynamics, origins (Wagner, Küssner, Theodorsen). Rodden and the Doublet Lattice Method (DLM)

- Continuing with 2D unsteady aerodynamics.
- The Finite Element Method (FEM) for aerodynamic analysis.
- Rodden and the Doublet lattice Method
- Aerodynamic corrections to match wind tunnel or flight tests.

The flutter equation and its solution (natural aircraft)

- Derivation of flutter equation from Lagrange equations.
- Complex matrix eigenvalues & eigenvector solution.
- Evolution of modal frequency and modal damping with flight speed.
- The V-g plot unveiled
- Physical description of classical lifting surface flutter mechanisms
- Airworthiness regulations CS25.629 (and the evolution from FAR 25.629 and JAR 25.629)

Flutter speed sensitivities. Control surface massbalance. Aeroservoelasticity (coupling with Flight Control System laws)

- Sensitivity analyses: mass configuration, Mach number, control surface aerodynamic hinge moment, etc.
- Physical description of classical control surface flutter mechanisms.

- Sensitivity to control surface mass balance.

- Covering uncertainties & addressing failure cases (structural single failures, damage tolerance, water ingress, composite delaminations...)

- Revisiting aircraft controls. Introduction to aircraft flight control system laws.

- Aeroservoelasticity.

- Physical description of most common aeroservoelastic couplings.

Flight Flutter Test. Aeroelastic model validation. Wrap up of aeroelastic stability problems.

- Flight Flutter Test (FVT) description.

- Aircraft response to control surface sweeps and pulses.

- Revisiting Digital Signal Processing (DSP). Noise treatment. Averaging. Windowing. Aliasing. Leakage,...

- Experimental Modal Analysis applied to Flight Test.

- Comparison between flight test and simulations. Scatter.

- Wrap up of aeroelastic stability problems.

The concept of loads. Monitoring stations. Checkstress loads and fatigue loads. Dynamic loads and why they are different form static loads. Structural response to transient excitation.

- What is fast and what is slow

- Direct response vs. Modal response

- Frequency domain response

- Time domain response

Ground dynamic loads: dynamic landing & Taxi

- Relevance

ASSESSMENT SYSTEM

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

In order to pass the subject, two requirements need to be met:

1) to have a MINIMUM mark of 4.0/10 in the end-of-term exam;
2) to have a minimum overall mark of 5.0/10 (weighing 60% the end-of-term exam mark and 40% the mark of the continuous evaluation).
3) Continuous evaluation will consist on:
- Class attendance & participation
- Homeworks (2 or 3 TBD)
- 3 partial exams. Those students passing the 3 partial exams with more than 5.0 in each one of them and having more than 7.0 as average among the three do not need to do the final exam. In this case final exam grade will correspond to the average grade of the partial exams.

BASIC BIBLIOGRAPHY

- Wright, J.R. and Cooper, J.E. Introduction to Aircraft Aeroelasticity and Loads, John Wiley & Sons, 2007

ADDITIONAL BIBLIOGRAPHY

- Bisplinghoff, R. L., Ashley, H., and Halfman, R.L. Aeroelasticity, Addison-Wesley, 1955

- Bisplinghoff, R., and Ashley, H. Principles of Aeroelasticity, Dover, 1962

- Dowell, E.H., Crawley, E.F., Curtiss, H.C., Peters, D.A., Scanlan, R.H. and Sisto, F. A Modern Course in Aeroelasticity (3rd ed), Kluwer, 1995

- Fung, Y.C. An Introduction to the Theory of Aeroelasticity, John Wiley and Sons, 1955

- Rodden, W.P. and Johnson, E.H. MSC/NASTRAN Aeroelastic Analysis User¿s guide., The MacNeal-Schwendler Corporation, 1994