Module Specification

Aero-Elasticity

Version: 2023-24, v6.0, 25 Jan 2023

Contents

Part 1: Information

Module title: Aero-Elasticity

Module code: UFMEWC-15-M

Level: Level 7

For implementation from: 2023-24

UWE credit rating: 15

ECTS credit rating: 7.5

Faculty: Faculty of Environment & Technology

Department: FET Dept of Engineering Design & Mathematics

Partner institutions: None

Field: Engineering, Design and Mathematics

Module type: Module

Pre-requisites: Aero Structures 2023-24

Excluded combinations: None

Co-requisites: None

Continuing professional development: No

Professional, statutory or regulatory body requirements: None

Part 2: Description

Overview: The module explores the concept of aeroelasticity and its effects on aircraft design. Students will be introduced to theoretical and experimental approaches to model , predict and validate aeroelastic effects and integrate aeroelastic effects into the engineering design process.

Features: Not applicable

Educational aims: See learning outcomes.

Outline syllabus: Introduction: Flutter, Aero-elasticity, Modes, Properties of stiffness matrices, freefree, applying constraints, Fixed root modes, Eigen solution Orthogonality of normal modes and transformation of multi-degree of freedom systems into modal equations, Free-free modes

Basic considerations: Wing inertial and flexural axes, Control surfaces, Static divergence, Control reversal, Influence on design, Strip theory – single element, Unsteady aerodynamics, Theodorsen, Minhinnick, frequency parameters, Aerodynamic stiffness and damping, Structural damping, 2 D.O.F. flutter equation, Classical equations to predict flutter speeds, Addition of control surfaces

Multi-strip fixed root wing bending torsion flutter: Stiffness properties, Calculation of wing modes and inertias, Orthogonal transform of mass and stiffness matrices to obtain modal set, 5 strip wing aerodynamics, Interpolate mode shapes onto strips, Assemble aerodynamic stiffness and damping, Flutter solution – needs flutter solution algorithm available, Effects of mass, flexural axis, frequency parameter, density, Types of flutter solution, matched and unmatched frequency parameter

Control surface flutter: How controls work, Attachment and control stiffness, Add freedom to wing model, Control surface flutter derivatives

Laboratory demonstration of free-free modes: Simple free-free beam, Shake test, Symmetric/asymmetric modes, Mode measurement and plotting

Free-free modes flutter: Symmetric/asymmetric, Symmetric flutter – pitch, vertical freedom and bending torsion, Comparison of mode shapes/inertias with fixed wing calculations earlier, Flutter analysis

Airframe modal characteristics: Wings, Tails, Engines, Weapons/stores, Complete airframe, Measuring modes, Representing free-free modes, Shake tests methods, Back to free-free model – prediction of forced response to shaker input – student exercise

Flutter testing: Purpose, Design requirements, Single, multiple failures, Store combinations, Excitation methods, Analysis methods, Telemetry, Flight envelope, Achieving speeds, Critical parts of envelope, Control system failure cases, Safety.

Part 3: Teaching and learning methods

Teaching and learning methods: Students will learn through a combination of formal lectures and tutorials sessions.

Module Learning outcomes: On successful completion of this module students will achieve the following learning outcomes.

MO1 Apply theoretical approaches to model and predict aircraft control surface flutter (P8m, P9m, EA1m)

MO2 Analyse the effects of aircraft control surface flutter through experimental approaches. (EA6m, D3m, P3)

MO3 Apply the principles of aero-elasticity for an aircraft and its components as part of the engineering design process. (EA2, P4m)

MO4 Critically evaluate the key aircraft design requirements and trade-offs which relate to structures, vibrations and aeroelasticity (EA1m, D7m, P6, G1)

Hours to be allocated: 150

Contact hours:

Independent study/self-guided study = 114 hours

Face-to-face learning = 36 hours

Total = 150

Reading list: The reading list for this module can be accessed at readinglists.uwe.ac.uk via the following link https://uwe.rl.talis.com/modules/ufmewc-15-m.html

Part 4: Assessment

Assessment strategy: The final assessment time constrained task (24 hours) where students demonstrate their ability to apply the principles presented to the aircraft design process including critical reflection of key requirements and trade-offs. Students will be provided with a number of outline scenarios prior to the assessment although the exact detail of the questions will be unseen.

Students are required to submit a recorded presentation on an aircraft design problem including theoretical modelling, prediction and experimental validation (30min).

There will be opportunities for formative feedback and feed-forward during tutorial and seminar sessions which focus on the application of aeroelasticity principles to relevant aerospace case studies.

The resit assessment strategy is the same as the first sit.

Assessment tasks:

Written Assignment (First Sit)
Description: Scenario-based involving use of case studies (24 hour coursework). Time constrained task.
Weighting: 50 %
Final assessment: Yes
Group work: No
Learning outcomes tested: MO1, MO3, MO4

Presentation (First Sit)
Description: Video recording of presentation on theoretical modelling and experimental validation.
Weighting: 50 %
Final assessment: No
Group work: No
Learning outcomes tested: MO1, MO2

Written Assignment (Resit)

Description: Scenario-based involving use of case studies (24 hour coursework). Time constrained task.

Weighting: 50 %

Final assessment: Yes

Group work: No

Learning outcomes tested: MO1, MO3, MO4

Presentation (Resit)

Description: Video recording of presentation on theoretical modelling and experimental validation.

Weighting: 50 %

Final assessment: No

Group work: No

Learning outcomes tested: MO1, MO2

Part 5: Contributes towards

This module contributes towards the following programmes of study:

Aerospace Engineering (Design) [Sep][FT][Frenchay][4yrs] - Not Running MEng 2020-21

Aerospace Engineering with Pilot Studies (Design) [Sep][FT][Frenchay][4yrs] - Not Running MEng 2020-21

Aerospace Engineering (Design) [Sep][SW][Frenchay][5yrs] MEng 2019-20

Aerospace Engineering with Pilot Studies (Design) [Sep][SW][Frenchay][5yrs] MEng 2019-20

Aerospace Engineering [Sep][FT][Frenchay][4yrs] MEng 2020-21

Aerospace Engineering with Pilot Studies [Sep][FT][Frenchay][4yrs] MEng 2020-21

Aerospace Engineering [Sep][FT][Frenchay][4yrs] - Not Running MEng 2020-21

Aerospace Engineering with Pilot Studies [Sep][FT][Frenchay][4yrs] - Not Running MEng 2020-21

Aerospace Engineering [Sep][SW][Frenchay][5yrs] MEng 2019-20

Aerospace Engineering with Pilot Studies [Sep][SW][Frenchay][5yrs] MEng 2019-20