Module Specification

Structural Mechanics

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Contents

Part 1: Information

Module title: Structural Mechanics

Module code: UFMFSS-30-2

Level: Level 5

For implementation from: 2021-22

UWE credit rating: 30

ECTS credit rating: 15

Faculty: Faculty of Environment & Technology

Department: FET Dept of Engineering Design & Mathematics

Partner institutions: None

Delivery locations: Frenchay Campus, University Centre Somerset, University Centre Weston

Field:

Module type: Standard

Pre-requisites: Solid Mechanics, Materials and Manufacturing 2020-21

Excluded combinations: None

Co-requisites: None

Continuing professional development: No

Professional, statutory or regulatory body requirements: None

Part 2: Description

Overview: This modules gives students access to methods of stress analysis to be used in the design of mechanical and aeronautical components. It builds on the basic first year modules of stress analysis and materials.

Students' knowledge of stress determining methods are greatly expanded so that

they can tackle standard situations, including statically indeterminate problems. By the end of this section, the students will be able to combine different loading types, extract principal stresses and apply failure criteria. While not strictly speaking “stresses”, this section also includes beam deflection, column buckling and strain transformation, as is customary with modern approaches and textbook.

Finite elements analysis (FEA) is then introduced as an extension of stress analysis, with an emphasis on practical skills to be able to use industry standards integrated codes and software (such as ANSYS and ABAQUS). The theory underpinning FEA is not neglected, but is presented in a trimmed down way in order to allow students to appreciate and quantify the approximations and hypotheses the method uses. In addition, the simplified stiffness matrix method used for this gives students an additional method to analyse statically indeterminate problems, contributing to a homogeneous feel to the module.

The way mechanical parts fail also depends on the material they are made of, and of the manufacturing processes used. Here again, students’ knowledge is expanded to cover the basics of fast fracture, fatigue and creep. This is rounded up by a very practical introduction to systematic materials and process selection, using the Ashby method.

Features: Not applicable

Educational aims: This module will develop the ability of students to apply stress analysis techniques and demonstrate understanding of material properties in more complex engineering situations including those where computational techniques are required.

Outline syllabus: Indicative Content (Syllabus) Stress Analysis:

Axially loaded members, introduction to statically indeterminate problems, stress concentration factors for axial loading
Eccentric and Asymmetric bending in beams, composite beams, stress concentration factors for bending
Deflection of beams and shafts (Euler-Bernoulli theory), including statically indeterminate problems, double integration method, introduction to Macauley’s

brackets
Column buckling (Euler theory), eccentric buckling (secant formula)
Transverse shear, shear flow in built-up and thin-walled members
Torsion loading, including non-circular shafts, stress concentration factors for torsional loading
Stress transformation, direct methods and Mohr's circle
Failure criteria (maximum shear, von Mises', Mohr's)
Strain transformation, strain gauges and rosettes

Finite Element Analysis:
Basics of continuous mechanics: loads, displacements, stress strains and relations (differential equations) between these.
Basic principles of FEA: elements, nodes, stiffness matrices (local and global), boundary conditions, intra-element interpolation (shape functions). Examples in 1D and 2D with bar elements only
3D static structural simulations with solid elements, conversion from CAD, basic meshing (mesh independence, mesh convergence, stress singularities)
2D/3D static structural simulations with surface and shell elements, advanced meshing techniques (mesh connections, mesh quality metrics)
1D static structural simulations with beam elements, link with theory
Static structural simulation of layered composites
(Self-taught through optional tutorials): mode analysis, transient (implicit) dynamics simulations, explicit dynamics simulations

Materials and Manufacturing:
Materials indices and materials selection
Manufacturing process selection
Elementary fracture mechanics (fracture toughness, critical crack size)
Elementary fatigue analysis (SN curves, Goodman's relation, Miller's rule)
Fatigue and crack growth (Paris law)

Part 3: Teaching and learning methods

Teaching and learning methods: The module will be taught using large cohort sessions to present the underlying concepts and principles supported by small group tutorials, lab sessions and computer practical sessions as appropriate where more detailed work and discussions on specific engineering problems will take place.

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

MO1 Effectively explain the scientific and mathematical principles of theoretical and experimental stress analysis of standard structural components. (SM1m, SM2m)

MO2 Describe in detail, material properties and the corresponding modes of failure, including dependence on manufacturing processes. (SM1m, SM2m)

MO3 Perform calculations and analyses with standard FEA codes, including hypotheses and results validation. (EA1m, EA2, EA3m)

MO4 Apply industry recognised methods for material selection for manufacturing, including the determination of indices and the use of standard databases. (EA2, EA3m)

MO5 Design realistic engineering components by solving complex problems involving general stress and failure analyses, using a combination of analytical and computational skills. (D3m, EL4, EL5, EL6, P8)

Hours to be allocated: 300

Contact hours:

Independent study/self-guided study = 228 hours

Face-to-face learning = 72 hours

Total = 300

Reading list: The reading list for this module can be accessed at readinglists.uwe.ac.uk via the following link https://rl.talis.com/3/uwe/lists/96B52288-0817-FAC6-0710-29A8852394D0.html

Part 4: Assessment

Assessment strategy: In this module it is important that students demonstrate their ability to apply stress analysis principles in structural design, to understand the relationships between continuous solid mechanics and FEA simulation tools and perform analysis of possible modes of failures that depend on materials properties.

To achieve the above objective the assessment strategy is designed with two components.

Component B will consist of a small group exercise involving an FEA analysis of a mechanical engineering problem resulting in a group report.

Component A will contain two elements;

A series of e-assessments to allow students to practice and gain rapid feedback on the use of standard calculation and analysis techniques.

A two hour examination that will assess the ability to apply these standard techniques under controlled conditions and also involve a pre-seen scenario where students are able to demonstrate problem formulation, analysis and interpretation of an engineering problem.

The resit assessment strategy will involve an individual report for component B and a repeat of the format for component A.

Assessment components:

Online Assignment - Component A (First Sit)
Description: Portfolio of short e-assessments involving standard calculations and analysis
Weighting: 10 %
Final assessment: No
Group work: No
Learning outcomes tested: MO1, MO2

Examination (Online) - Component A (First Sit)
Description: Theoretical Stress Analysis, FEA and Materials/Manufacturing mixture of standard calculations and pre-seen scenario: Online Exam: 3 hours
Weighting: 55 %
Final assessment: Yes
Group work: No
Learning outcomes tested: MO1, MO2, MO4, MO5

Report - Component B (First Sit)
Description: FEA and Materials selection: group report (2500 words)
Weighting: 35 %
Final assessment: No
Group work: Yes
Learning outcomes tested: MO1, MO3

Online Assignment - Component A (Resit)
Description: Short e-assessments to allow practice and rapid feedback on standard stress calculations and analysis
Weighting: 10 %
Final assessment: No
Group work: No
Learning outcomes tested: MO1, MO2

Examination (Online) - Component A (Resit)
Description: Theoretical Stress Analysis, FEA and Materials/Manufacturing: Online Exam involving standard stress analysis calculations and analysis and a pre-seen scenario: 3 hours
Weighting: 55 %
Final assessment: Yes
Group work: No
Learning outcomes tested: MO1, MO2, MO4, MO5

Report - Component B (Resit)

Description: FEA and Materials selection: individual report (1500 words)
Weighting: 35 %
Final assessment: No
Group work: No
Learning outcomes tested: MO1, MO3

Part 5: Contributes towards

This module contributes towards the following programmes of study:

Mechanical Engineering {Apprenticeship-UCW} [Sep][FT][UCW][3yrs] FdSc 2020-21

Automotive Engineering [Sep][SW][Frenchay][4yrs] BEng (Hons) 2020-21

Aerospace Engineering [Sep][FT][Frenchay][3yrs] BEng (Hons) 2020-21

Aerospace Engineering [Sep][SW][Frenchay][4yrs] BEng (Hons) 2020-21

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

Aerospace Engineering [Sep][SW][Frenchay][5yrs] MEng 2020-21

Aerospace Engineering with Pilot Studies [Sep][FT][Frenchay][3yrs] BEng (Hons) 2020-21

Aerospace Engineering with Pilot Studies [Sep][SW][Frenchay][4yrs] BEng (Hons) 2020-21

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

Aerospace Engineering with Pilot Studies [Sep][SW][Frenchay][5yrs] MEng 2020-21

Aerospace Engineering {Apprenticeship-UCW} [Sep][FT][UCW][4yrs] BEng (Hons) 2020-21

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

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

Mechanical Engineering [Sep][SW][Frenchay][5yrs] MEng 2020-21

Mechanical Engineering [Sep][FT][Frenchay][3yrs] BEng (Hons) 2020-21

Mechanical Engineering [Sep][SW][Frenchay][4yrs] BEng (Hons) 2020-21

Automotive Engineering [Sep][SW][Frenchay][5yrs] MEng 2020-21

Automotive Engineering [Sep][FT][Frenchay][3yrs] BEng (Hons) 2020-21

Mechanical Engineering with Manufacturing {Apprenticeship-UWE} [Sep][FT][UCW][4yrs] BEng (Hons) 2020-21

Mechanical Engineering {Apprenticeship-GlosColl} [Sep][FT][GlosColl][3yrs] FdSc 2020-21

Aerospace Engineering {Apprenticeship-UCW} [Sep][FT][UCW][5yrs] BEng (Hons) 2020-21

Aerospace Engineering {Apprenticeship-UWE} [Sep][FT][UCW][4yrs] BEng (Hons) 2020-21

Mechanical Engineering {Apprenticeship-UCS} [Sep][FT][UCS][3yrs] FdSc 2020-21

Mechanical Engineering with Manufacturing {Apprenticeship-UWE} [Sep][FT][COBC][4yrs] BEng (Hons) 2020-21