Prifysgol Wrecsam
Wrexham University

Module specification

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Module Code	ENG5AT
Module Title	Structures Analysis and Finite Element Analysis
Level	5
Credit value	20
Faculty	FACE
HECoS Code	101396
Cost Code	GAME
Pre-requisite module	None

Programmes in which module to be offered

Programme title	Core/Optional/Standalone
BEng (Hons) Mechatronics Engineering	Core

Breakdown of module hours

Learning and teaching hours	60 hrs
Placement tutor support hours	0 hrs
Supervised learning hours e.g. practical classes, workshops	0 hrs
Project supervision hours	0 hrs
Active learning and teaching hours total	**0** hrs
Placement hours	0 hrs
Guided independent study hours	140 hrs
Module duration (Total hours)	200 hrs

Module aims

To develop an understanding and an overall appreciation of the processes that lead to developing an appropriate structure to satisfy given requirements. Design considerations include the assessment: of bucking of struts in structures with various end conditions; of beams deriving equations relating to the Engineer's Theory of Bending and also bending in symmetric and asymmetric structures; leading on to the consideration of shear stress distributions in beams and introducing the concept of shear flows.

Develop the theory of linear elastic fracture mechanics along with concepts of plane stress and plane strain at the crack-tip.

To develop an understanding of fast fracture leading onto fatigue with S/N diagrams and crack growth laws to determine component life are considered.

To gain a basic theoretical and practical understanding of the technique of finite elements with knowledge of how to apply the technique to simple problems.

Module Learning Outcomes

At the end of this module, students will be able to:

1	Relate an overall design philosophy to the design of structures.
2	Use a range of analysis techniques, namely: buckling analysis on simple struts, E.T.B. on symmetric and asymmetric structures, flexural and shear stress distributions on beams subjected to combinations of loads.
3	Ascertain where failure might occur, including the conditions that might produce the failure and evaluate the relevance of results.
4	Simulate with an appropriately specified finite element model a very simple structure and be able to interpret the results. An appreciation of whether the model offers a converged solution should be gained.

Assessment

Indicative Assessment Tasks:
This section outlines the type of assessment task the student will be expected to complete as part of the module. More details will be made available in the relevant academic year module handbook.

Assessment 1: A 2-hour examination covering outcomes 1 to 3. It is an unseen time constrained examination.

Assessment 2: A written assignment covering outcome 4.

Assessment number	Learning Outcomes to be met	Type of assessment	Duration/Word Count	Weighting (%)	Alternative assessment, if applicable
1	1, 2, 3	Examination	2 hrs	60%	
2	4	Written Assignment	2500	40%	

Derogations

None

Learning and Teaching Strategies

The module will be presented to students through lectures, tutorials, and computer-based laboratory investigations. The tutorials and computer-based laboratory investigations will be used for students to practice problem solving to reinforce the lecture material and to provide individual attention where needed.

The finite element work will be primarily computer laboratory based with practical exercises supported by introductory lectures and demonstrations. The emphasis will be directed towards on hand-on learning via a commercial software package.

Welsh Elements

Programme is delivered in English and Chinese, however students can submit assessments in Welsh.

Indicative Syllabus Outline

Stress and Strain: material classification: isotropic, orthotropic, anisotropic. Poisson’s ratio. Two dimensional problems. Volumetric strain. Bulk modulus. Elastic constants.

Complex Stress and Strain: Complementary shear stress. Complex stress situation/formulae. Principal stresses, maximum shear stress and associated planes. Mohr’s circle. Principal strains. Direct strain measurements. Relationship and calculation of principal stresses from principal strain values.

(Thin Cylinder and Thick Cylinder Theory: Thin cylinder: Stresses, increase in volume due to internal pressure. Lame’s equations for thick cylinders. Lame’s equations to solve engineering problems.)

Torsion Analysis: Torsion of a circular bar; Torsion of a hollow circular bar; Strain energy in torsion; Thin-wall tubes; Inelastic torsion bars. Theorem of Parallel Axes. Second moment of area about the neutral axis for common sections. Stress distribution diagrams for combinations of direct and bending stress.

Beam Analysis: Differential equation of bending. Applications to beams. Formulae for slope and deflection. Macaulay’s method for determining slope and deflection, various loading conditions.

Statically Indeterminate Beams: Statically indeterminate beams; Differential equation of the deflection curve; Method of superposition; Moment area method; Finite difference Method.

Structural Instability: Classical theory considering Euler buckling of perfect columns. Equations giving theoretical critical buckling loads for given end conditions. The concept of equivalent strut length. Limitations of the theory of Euler buckling.

Theory of Bending: Formal derivation and assumptions of equations of ETB are made with a revision of the concepts of 1st, 2nd moments of area, including parallel axis theorem. The concept of product moment of area is introduced. ETB is extended to the derivation of the curvature-bending moment relationship.

Asymmetric Bending: The theory and method of identifying the location of the principal axes of an unsymmetrical section. Magnitude of the principal and product moments of o area and their orientation. Skew loading applied to the section and the position/orientation of the neutral axes. Stresses within a section.

Shear Stress: The shear stress distribution due to bending for a given section. Thin-walled sections. Position of the shear centre for open thin-walled sections. The concept of shear flow.

Fatigue: The concept of a Griffith crack and Linear Elastic Fracture Mechanics. Fast fracture, strain energy release rate, stress intensity factors. Conditions of plane stress and plane strain at the crack tip. Crack growth laws such as Paris and their use in crack growth rate predictions.

Finite Element Analysis: Introductory lecture(s) into the technique of finite elements. An initial experience with proprietary finite element software package such as ANSYS and its use to solve (a) simple problem(s).

Indicative Bibliography

Please note the essential reads and other indicative reading are subject to annual review and update.

Essential Reads:

Hibbeler, R.C. (2014) Mechanics of Materials, 9th ed., Singapore: Pearson.

Other indicative reading:

Megson, T.H.G. (2013) Aircraft Structures for Engineering Students, 5th ed., Boston: Elsevier.

Ashby, M.F. (2011) Materials Selection in Mechanical Design, 4th ed., Burlington: Butterworth-Heinemann.

Zienkiewicz, O.C.,Taylor, R.L. (2013) The Finite Element Method: Its Basis and Fundamentals, 7th ed., Amsterdam: Elsevier.

Administrative Information

For office use only	
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Date and details of revision	22/07/2025 revalidated, updated template, derogation removed
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