Engineering Analysis

Module Information

2022.01, Approved

Summary Information

Module Code	6102MECH
Formal Module Title	Engineering Analysis
Owning School	Engineering
Career	Undergraduate
Credits	20
Academic level	FHEQ Level 6
Grading Schema	40

Teaching Responsibility

LJMU Schools involved in Delivery
Engineering

Learning Methods

Learning Method Type	Hours
Lecture	14
Online	11
Tutorial	11

Module Offering(s)

Display Name	Location	Start Month	Duration Number Duration Unit
SEP-CTY	CTY	September	12 Weeks

Aims and Outcomes

Aims	The module will introduce students to computational engineering analysis using finite element analysis (FEA) and computational fluid dynamics (CFD) and will extend their experience and skill with the aid of industry standard software.

After completing the module the student should be able to:

Learning Outcomes

Code	Number	Description
MLO1	1	Set up and validate efficient and accurate FEA and CFD models
MLO2	2	Identify the limitations of FEA and CFD as part of the design process
MLO3	3	Critically evaluate the output from FEA and CFD analysis
MLO4	4	Apply the theory underpinning commercial FEA and CFD codes

Module Content

Outline Syllabus	Practical aspects of FEAModelling strategy. Planning the analysis. Loading, point loads, stress singularities, pressure loading, examples. Boundary conditions, use of symmetry, balanced loading and minimum constraint avoidance of free body motion, problems associated with inappropriate boundary conditions, basic contact in assemblies, examples.Choice of element, mesh controls and mesh density, convergence of results, problems with element distortion, adaptive meshing. Managing the solution, types ofsolver, analysis of errors and warnings.Post processing and results checking. Review of available results, stress, strain, displacement, primary and derived quantities etc. Interpretation of results, checking results, reaction forces, displaced shape, nodal and element plots, hand calculations.Thermal analysis and thermal stress analysis. Planning the analysis, steady state, transient. Boundary conditions, temperature, convection, heat flux, radiation, solution output, temperature distribution, derived field quantities. Thermal stress analysis, sequential, coupled (description only) transfer of mesh and nodal temperatures to structural analysis. ExamplesModal Dynamics. Brief description of eigenvalue extraction techniques. Planning the analysis, boundary conditions, number of modes to extract, symmetry conditions,interpretation of results output. ExamplesShell and beam modelling. Modelling thin components, shells. Modelling using beam elements. Mixed meshing, solids, shells and beams. ExamplesTheoretical aspects of FEAReview of matrix algebra, matrix representation of linear simultaneous equations, types of matrix, multiplication, transpose, inverse, quadratic form, solution of equations using Gaussian elimination or equivalent. General FEA principles, application to simple one dimensional problems, comparison with traditional methods. Example using two stepped bar elements represented as springs, conceptof nodes and elements, element stiffness matrix determination by direct approach, incorporation of loads and BC's, solution.Global stiffness matrix assembly and solution. Example using three or more springs,derivation of element stiffness matrix using direct approach, element connectivity and assembly of global stiffness matrix, incorporation of loads and BC's to remove singularity, solution. Bandwidth and alternative element connectivity. Multiple load cases.Practical aspects of CFDUse of a commercial CFD code to solve engineering problems.Approach to setting up a CFD model. Identification of the underlying physics applicable for a given problem. Prediction of expected results based classical theory and rough hand calculations. Examination of the typical boundary conditions available within a commercial CFD code and the study of their validity. Selection of the boundary conditions required to capture the expected physical behaviour at the limits of the modelled region. Economic use of CFD, run time and computing resources required. Strategies to reduce the size of model required, use of symmetry in 2D and 3D models, transfer of boundary conditions from other models.Meshing quality, mesh construction and strategies for mesh refinement, mesh independence, adaptive mesh refinement. Selection of an appropriate computational domain for external flows, refinement and optimisation of computational domain dimensions.Monitoring the solution process, convergence control and relationships between convergence criteria and accuracy of solution, strategies for economic solution. Simultaneous solution of mass and heat transfers (conjugate heat transfer) including flow freezing and its effects on solution time. Use and control of solution adaptive mesh refinement techniques and implications for run time and storage requirements.Presentation and interpretation of CFD results. Extracting performance indicators, point values, surface integrals for loads and mean values of physical parameters. Strate
Module Overview	The module will introduce computational engineering analysis using finite element analysis (FEA) and computational fluid dynamics (CFD) and will extend your experience and skill with the aid of industry standard software.
Additional Information	An important feature of the module is that the students gain an understanding of the need to adopt a disciplined approach when using numerical CAE tools within an engineering environment. During the module the students must demonstrate an approach to analysis that guarantees the production of accurate, physically sound and well validated results. The module will introduce the students to suitable FEA and CFD methodologies. Whilst the theoretical aspects of the methods will be covered in lectures the module is intended to be practical in nature with students having the opportunity to practice via a range of tutorials and assignments using industry standard software. The module assignments will require that the students drive the software tools in a competent and professionally sound manner.

Assessments

Assignment Category	Assessment Name	Weight	Exam/Test Length (hours)	Module Learning Outcome Mapping
Centralised Exam	Invigilated FEA VLE Test	50	0	MLO1, MLO2, MLO3, MLO4

Test	Invigilated CFD VLE Test	50	0	MLO1, MLO2, MLO3, MLO4

Module Contacts

Module Leader

Contact Name	Applies to all offerings	Offerings
Ariyan Ashkanfar	Yes	N/A

Partner Module Team

Contact Name	Applies to all offerings	Offerings