Unit 37: Virtual Engineering

Unit	**Y/615/1505**
Unit level	**5**
Credit value	**15**

Introduction

The work of an engineer increasingly involves the use of powerful software modelling tools (virtual modelling). These tools allow us to predict potential manufacturing difficulties, suggest how a product or component is likely to behave in service, and undertake rapid and low cost design iteration and optimisation, to reduce costs, pre-empt failure and enhance performance.

This unit introduces students to the application of relevant Computer Aided Design (CAD) and analysis engineering tools in contemporary engineering. They will learn about standards, regulations and legal compliance within the context of engineering.

Topics included in this unit are: dimensioning and tolerances, standardisation and regulatory compliance (BS, ASTM, ISO, etc.), material properties and selection, manufacturing processes, 2D, 3D, CAD, solid modelling, one-dimensional and multi-dimensional problems, meshing and boundary conditions, and the finite volume method.

On successful completion of this unit students will be able to consider how to perform computational fluid dynamics (CFD) simulations, develop finite element product and system models, explain the identification of faults in the application of simulation techniques and discuss the modelling method and data accuracy.

Learning Outcomes

By the end of this unit students will be able to:

1. Explore the capabilities and limitations of computer-based models in meeting design fundamentals and their use in solving problems in engineering.
2. Analyse finite element product and system models in order to find and solve potential structural or performance issues.
3. Perform CFD simulations to evaluate pressure and velocity distributions within an engineering setting.
4. Determine faults in the application of simulation techniques to evaluate the modelling method and data accuracy.

Essential Content

LO1 **Explore the capabilities and limitations of computer-based models in meeting design fundamentals and their use in solving problems in engineering**

Engineering design fundamentals:

Dimensioning and tolerances

Standardisation and regulatory compliance (BS, ASTM, ISO, etc.)

How to manufacture and what to manufacture:

Material properties and selection

Manufacturing processes: capability, cost issues and selection

Design tools:

2D and 3D CAD

Solid modelling

File types, export and compatibility

Interpretation and presentation of results through a series of guided exercises:

Results obtained, comparison of data, benefits and limitations

Generalisation of provided information, recommendations on current and future applications

LO2 **Analyse finite element product and system models in order to find and solve potential structural or performance issues**

Finite element formulation:

One-dimensional problems

Multi-dimensional problems

Beams

Finite element method:

Define the problem: simplify an engineering problem into a problem that can be solved using FEA

Define material properties and boundary conditions; choose appropriate functions, formulate equations, solve equations, visualise and explain the results

LO3 **Perform CFD simulations to evaluate pressure and velocity distributions within an engineering setting**

Fundamentals of CFD (Computational Fluid Dynamics):

CFD and the finite volume method background

Meshing and boundary conditions

Applications, advantages and limitations of CFD

CFD simulation and analysis:

Apply CFD to simple design/aerodynamics problems: define the problem, provide initial boundary conditions for the problem, set-up a physical model, define material properties and operating conditions

Interpretation of CFD results

Examine the solution using graphical and numerical tools; suggest and make revision of the models

LO4 **Determine faults in the application of simulation techniques to evaluate the modelling method and data accuracy**

Simulation results:

Extracting relevant information from simulation-based exercises

Interpretation and presentation of results through a series of guided exercises

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Explore the capabilities and limitations of computer-based models in meeting design fundamentals and their use in solving problems in engineering</td><td rowspan="2">D1 Critically evaluate and provide supported recommendations for the application of computer-based models to an industrial environment that would improve efficiency and problem-solving</td></tr>
<tr><td>P1 Discuss the benefits and pitfalls of computer based models used within an industrial environment to solve problems in engineering</td><td>M1 Evaluate the capabilities and limitations of computer-based models

M2 Evaluate the processes and applications used in solving problems in engineering</td></tr>
<tr><td colspan="2">LO2 Analyse finite element product and system models in order to find and solve potential structural or performance issues</td><td rowspan="2">D2 For a range of practical examples, provide supported and justified recommendations for recognising and solving potential structural or performance-based issues, using finite element product and systems models</td></tr>
<tr><td>P2 Analyse the role of finite element analysis in modelling products and systems

P3 Review a range of practical examples to solve potential structural or performance-based issues using finite element product and systems models</td><td>M3 Critically analyse the finite element product and systems models that help to find and solve potential performance or structural issues for a range of practical examples</td></tr>
</table>

Pass	Merit	Distinction
LO3 Perform CFD simulations to evaluate pressure and velocity distributions within an engineering setting		**D3** Provide supported and appropriate recommendations for improving efficiency and the generation of suitable meshes for CFD simulations
P4 Demonstrate the importance of CFD simulations applied to evaluate pressure and velocity distributions in the engineering setting **P5** Complete CFD simulation to evaluate pressure and velocity distributions within an engineering setting	**M4** Evaluate the application and limitations of CFD in an engineering context	
LO4 Determine faults in the application of simulation techniques to evaluate the modelling method and data accuracy		**D4** Critically evaluate the appropriate application of simulation techniques that can support decision-making
P6 Determine the faults in the application of simulation techniques **P7** Discuss and evaluate the modelling method and data accuracy	**M5** Extract relevant information from simulation **M6** Trace potential faults in the application of simulation techniques **M7** Critically review results through a series of guided exercises and recommendations	

Recommended Resources

Textbooks

DATE, A.W. (2005) *Introduction to Computational Fluid Dynamics*. Cambridge University Press.

FISH, J. and BELYTSCHKO, T. (2007) *A First Course in Finite Elements*. Wiley.

TREVOR, H. and BECKER, A.A. (2013) *Finite Element Analysis for Engineers*. A Primer, National Agency for Finite Element Methods & Standards.

Websites

www.tandfonline.com	Taylor & Francis Online International Journal of Computational (Journal)
http://www.inderscience.com/	Inder Science Publishers Progress in Computational Fluid Dynamics, An International Journal (Journal)
https://www.nafems.org/	NAFEMS International Journal of CFD Case Studies (Journal)

Links

This unit links to the following related units:

Unit 1: Engineering Design

Unit 50: Advanced Manufacturing Technology