LIVERPOOL JOHN MOORES UNIVERSITY

# Module Proforma

**Approved, 2022.01**

## Summary Information

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|---|---|
| **Module Code** | 6565USST |
| **Formal Module Title** | Computational Fluid Dynamics |
| **Owning School** | Engineering |
| **Career** | Undergraduate |
| **Credits** | 10 |
| **Academic level** | FHEQ Level 6 |
| **Grading Schema** | 40 |

## Module Contacts

### Module Leader

| Contact Name | Applies to all offerings | Offerings |
|---|---|---|
| Dante Matellini | Yes | N/A |

### Module Team Member

| Contact Name | Applies to all offerings | Offerings |
|---|---|---|

### Partner Module Team

| Contact Name | Applies to all offerings | Offerings |
|---|---|---|

## Teaching Responsibility

| LJMU Schools involved in Delivery |
|---|
| LJMU Partner Taught |

## Partner Teaching Institution

| Institution Name |
| --- |
| University of Shanghai For Science and Technology |

## Learning Methods

| Learning Method Type | Hours |
| --- | --- |
| Lecture | 11 |
| Tutorial | 11 |

## Module Offering(s)

| Offering Code | Location | Start Month | Duration |
| --- | --- | --- | --- |
| JAN-PAR | PAR | January | 12 Weeks |

## Aims and Outcomes

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| --- | --- |
| **Aims** | The module will introduce students to Computational Fluid Dynamics (CFD) and will extend their experience, knowledge and skill with the aid of industry standard software. |

## Learning Outcomes

**After completing the module the student should be able to:**

| Code | Description |
| --- | --- |
| MLO1 | Understand and apply the theory underpinning commercial CFD codes. |
| MLO2 | Set up and validate efficient and accurate CFD models. |
| MLO3 | Critically evaluate the output from CFD analysis. |
| MLO4 | Identify the limitations of CFD as part of the design process. |

## Module Content

| Outline Syllabus |
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| Theoretical aspects of CFD:<br><br>- Qualitative revision of real fluid flow and introduction to CFD with industrial examples of usage.<br>- Review of the governing equations of fluid flow including Navier-Stokes equations, energy equations and continuity equations.<br>- Discretisation of the computational domain and numerical solution of the resulting algebraic equations.<br>- Problems with direct matrix inversion and need for iterative solution methods. Basic iterative schemes, Gauss-Seidel and Jacobi, solution behaviour, convergence, stability, under and over relaxation.<br>- Meshing principles and strategies to improve meshing.<br>- Introduction to the modelling of boundary layer flow, law of the wall (wall function) and its use in CFD modelling.<br>- Turbulence - qualitative understanding. Brief introduction to time averaging and need for a turbulence model.<br>- Validation and verification of CFD simulations.<br><br>Practical aspects of CFD:<br><br>- Use of a commercial CFD code to solve engineering problems.<br>- Approach to setting up a CFD model.<br>- Identification of the underlying physics applicable for a given problem.<br>- Prediction of expected results based classical theory and rough hand calculations.<br>- Examination of the typical boundary conditions available within a commercial CFD code and the study of their validity.<br>- Selection of the boundary conditions required to capture the expected physical behaviour at the limits of the modelled region.<br>- Economic use of CFD, run time and computing resources required.<br>- Strategies to reduce the size of model required, use of symmetry in 2D and 3D models, transfer of boundary conditions from other models.<br>- Meshing quality, mesh construction and strategies for mesh refinement, mesh independence, adaptive mesh refinement.<br>- Selection of an appropriate computational domain for external flows, refinement and optimisation of computational domain dimensions.<br>- Monitoring the solution process, convergence control and relationships between convergence criteria and accuracy of solution, strategies for economic solution.<br>- 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.<br>- Presentation and interpretation of CFD results. Extracting performance indicators, point values, surface integrals for loads and mean values of physical parameters.<br>- Strategies for validation of results including checking of conservation laws, mesh and computational domain independence, comparison with existing data/theory. |

### Module Overview

| Additional Information |
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| This module includes content which relates to the following UN Sustainable Development Goals. Computational Fluid Dynamics (CFD) has become an invaluable tool in the design process of any problem involving fluid flow phenomena. Therefore, the following UN Sustainable Development Goals are, in part, considered:<br><br>SDG3 – CFD is used in the investigation of blood flow in diseased arteries (i.e. atherosclerosis) and air flow through lungs. These will be considered in the tutorial sessions.<br>SDG6 – CFD is used in the development of systems that provide clean water and sanitation which is considered in a tutorial.<br>SDG7 – CFD is used in the design of systems that provide affordable and clean energy (e.g. wind turbines, tidal stream turbines) which are considered in a tutorial.<br>SDG9 – CFD is used in industry, innovation (novel products) and infrastructure.<br>SDG11 – CFD is used in the design of sustainable cities and communities whether it be considering the wind profile through large buildings or sewer system. These aspects will be considered in the tutorials.<br>SDG12 – CFD is used in the development of systems that allow for responsible consumption and production.<br>SDG13 – CFD is used in the development of systems that provide for clean, renewable energy supplies playing a role in climate action. |

## Assessments

| Assignment Category | Assessment Name | Weight | Exam/Test Length (hours) | Learning Outcome Mapping |
| --- | --- | --- | --- | --- |
| Exam | Exam | 100 | 3 | MLO1, MLO2, MLO3, MLO4 |