Module Details	
Module Title	Transport Phenomena
Module Code	CPE7011-B
Academic Year	2020/1
Credits	20
School	Department of Chemical Engineering
Subject Area	Chemical and Process Engineering
FHEQ Level	FHEQ Level 7
Pre-requisites	N/A
Co-requisites	N/A

Contact Hours	
Type	Hours
Laboratories	8
Online Tutorials (Synchronous)	12
Online Lecture (Synchronous)	20
Directed Study	160

Availability	
Occurrence	Location / Period
BDA	University of Bradford / Semester 1

Module Aims
The module treats the fundamental phenomena of momentum, energy, and mass transport, emphasising throughout the analogies between them. It establishes the mathematical framework of the conservation equations (continuity, motion and energy) and the corresponding constitutive equations (Newton?s law of viscosity, Fourier?s law of heat conduction and Fick?s law of diffusion). These are then applied to analyse various flow, heat transfer and mass transfer situations of importance to chemical engineering and obtain exact analytical solutions to steady state, unidirectional Newtonian and non-Newtonian flow problems and to steady-state heat and mass transfer problems. In addition, students are introduced to the use of CFD packages to solve situations not possible analytically.

Outline Syllabus
1. Introduction to TP, historical perspective to present day CFD modelling - Types of Transport Phenomena: Momentum, Energy, Mass - Corresponding Constitutive Transport Equation: Newton?s, Fourier?s and Fick?s laws. 2. Momentum Transport - Viscosity and the mechanism of momentum transport - Conservation of Mass and Momentum Equations, laminar and turbulent flow 3. Momentum Transport - Application to isothermal laminar flow in pipe - Application to isothermal turbulent flow in pipe 4. Tutorial Class on Momentum Transport 5. Energy Transport - Fourier?s law of heat conduction - Temperature distributions in solid and laminar flow - Interphase Energy Transport (Heat Transfer Coefficient) - Conservation of Energy Equation 6. Tutorial Class on Energy Transport - Application to non-isothermal flow in pipes 7 and 8. CFD Simulations of Momentum and Energy Transport situations. Interactive sessions & group work on usage of CFD packages, e.g. Fluent 9. Mass Transport - Diffusivity and the mechanisms of mass transport - Concentration distributions in solids and in laminar flow 10. Mass Transport - Interphase mass transport (Mass Transfer Coefficient) 11. Tutorial Class on Mass Transport - Ordinary diffusion in gases and liquids. - Diffusion in solids and in laminar flow - Interphase transport 12. Consolidation of learning objectives session - Similarities between momentum, energy and mass transfer.

Learning Outcomes	
Outcome Number	Description
01	Critically evaluate the principles of momemtum, energy and mass transports and apply these principles to the analysis and design of flow, heat transfer and mass transfer situations. [SM1b, SM3b, EA1b, EA2, D2, P1, P2, G2].
02	Interpret data, use mathematical methods and solve problems systematically [EA1b, EA3b, G1]
03	IIdentify transport properties and analyze the mechanisms of molecular momentum, energy and mass transport [EA2, P2, G2].
04	Select coordinate systems for transport phenomena problems and formulate the differential forms of the equations of change for momentum, heat and mass transfer problems for steady-state and unsteady flows. [EA1b,EA3b,G1]
05	Use CFD packages to obtain non analytical solutions to more complex fluid flow, heat transfer and mass transfer problems [EA1,EA3b,G1].

Learning, Teaching and Assessment Strategy

The section in italics below refers to pre-pandemic conditions which had to be revised as shown under heading ?Changes of Delivery and Assessment following COVID-19"

Theory, implementation, application, and critical analysis is gained through interactive lectures, tutorials, CFD workshops and directed study.

The lectures will be organised so that the students participate by organising them in groups in the class and assigning to them points of discussion throughout the lecture.

The tutorials will be organised so that the students work in groups discussing the problem at hands and its solution. Each group will be asked to raise and share questions with the rest of the class.

All lecture notes and tutorial questions and their solutions will be posted on the VLE.

CFD application and evaluation is gained using CFD package Fluent installed on dedicated computers in the School. The learning outcome here is to develop skills in using chemical engineering transport processes software packages that are routinely used in industry.

The coursework is intended to consolidate the CFD skills. It consists of a CFD analysis of a particular chemical engineering transport process.The course work (analysis and solution) is to be presented in a concise critical report thus furthering the learning of presentation skills.

The learning outcomes covered by the examinations include an understanding of the fundamental principles of momentum, energy and mass transports and application of these principles to the analyses of chemical engineering transport processes.

Assessment of understanding, application and critical analysis is carried out through one 2 hr formal examination (50%) at the end of Semester 1 and one piece of course work (50%) carried out in groups for the first assessment or individually for the supplementary assessment.

The examination questions are constructed to cover the entire curriculum (LO1-5) with marks allocation clearly identified in the question parts.

The coursework consists of a CFD analysis of a particular chemical engineering transport process carried out individually or in groups (LO5).

The course work (analysis and solution) is to be presented in a concise critical report. For group course work, summative peer evaluation by the group members will be taken into account when calculating the final individual mark (LO5).

Formative assessment will take the form of a mock examination in week 10 followed by feedback and remedial revisions.

Changes of delivery and assessment following COVID-19:

DELIVERY: Lectures and tutorials will be given online via zoom enabling interaction through the

chat command, questions to which I will answer. Students will also be encouraged to post

questions on Canvas or by emails. Answers will be posted on Canvas together with copies of the

ppt and zoom videos of the lectures/tutorials.

Preparation for the CW require training on FLUENT software, training which will be carried out at the university (2 x 2hr sessions in Weeks 5 and 6 of the Semester). ASSESSMENT: Unless instructed otherwise, assessment will be by open book online examination and CW as described. The examination will be undertaken under the conditions decided by the university regarding conduct, start time and submission of the online examination. Preparation for the examination will be conducted in Week 12 of the Semester via an online zoom session videoed and posted on Canvas together with past examination questions. Throughout the semester, solutions to tutorial examples will be explained and posted on Canvas.

Mode of Assessment

Type	Method	Description	Length	Weighting
Summative	Examination - Open Book	Answer 3 questions	2 hour	50%
Summative	Coursework	One group report based on a CFD analysis of a flow, heat transfer or mass transfer problem verified by analytical sols	N/A	50%

Reading List

To access the reading list for this module, please visit https://bradford.rl.talis.com/index.html

Please note:
This module descriptor has been published in advance of the academic year to which it applies. Every effort has been made to ensure that the information is accurate at the time of publication, but minor changes may occur given the interval between publishing and commencement of teaching. Upon commencement of the module, students will receive a handbook with further detail about the module and any changes will be discussed and/or communicated at this point.
