UNIVERSITY OF BIRMINGHAM

College of Engineering and Physical Sciences

School of Chemical Engineering

Centre for Fuel Cell & Hydrogen Research

Fuel Cell and Hydrogen Technologies - Winter 2025 CPD course programme

Contents

Welcome to the School of Chemical Engineering within the University of Birmingham!

We are very happy that you have requested further information on the Continuous Professional Development (CPD) courses at the University of Birmingham, and – what is more – chosen our fuel cell and hydrogen courses. We want you to make the most of the opportunities offered, so please read the information in this programme brochure.

Chemical Engineering is one of the largest Schools at University and in the College of Engineering and Physical Sciences (EPS). We regularly have around 150 undergraduate students registering for 1st Year. We do not have any overly formal structures. The main specialisations in School are in Formulation Engineering (a lot of food and pharmaceuticals-related research, including fun-stuff such as cake, chocolate, and beer), a growing Healthcare section, Bio-Chemical Engineering, and the Energy work, which includes the Centre for Energy Storage, the Centre for Sustainable Cold, and the Centre for Fuel Cell and Hydrogen Research, which hosts the CPD programmes you have enrolled on.

As Chemical Engineers, you will find that we are an interdisciplinary bunch of people with a broader approach to knowledge and expertise than can be found in other engineering subjects. A bad thing, and a good thing (as usual): more learning material we offer you for studies and more involved tasks to solve, but you will be rewarded by a wider knowledge and potentially better employment opportunities.

We hope that this programme overview will contain answers to most of your questions. However, if you cannot find an answer to a question, please do not hesitate to contact us by e-mail.
We very much hope that you will enjoy your time with us.

Prof Dr Robert Steinberger-Wilckens
Programme lead MSC Fuel Cell & Hydrogen Technologies, and
Director of the Centre for Fuel Cell & Hydrogen Research, CFCHR.
e-mail: r.steinbergerwilckens@bham.ac.uk

Programme Information

Background

The MSc in Fuel Cell and Hydrogen (MSc FCH) offered by the School of Chemical Engineering at the University of Birmingham since Sept 2021 was the first-of-its-kind delivery in Europe, addressing an immediate need of the UK (and global) industry in fuel cell and hydrogen technologies as part of a nationwide and global drive for more efficient and sustainable energy conversion and supply.

As fuel cells and electrolysers increasingly penetrate the market for clean energy technologies, there is increasing demand from a diverse range of industries ranging from transport, including automotive, shipping and aeronautics, through to lightweight state-of-the-art portable generator and off-grid applications, and finally pollution-free grid-connected power generation to buildings, for refrigeration, and backup and uninterruptible power supply.

Hydrogen today is already a large-scale commodity in industry (refineries, chemical industry, fertilizer production etc.). As we add new applications, such as electrical transport, we broaden the spectrum of use, but also exploit the properties of hydrogen in enabling zero-carbon energy conversion.

Hydrogen and fuel cells are not necessarily closely linked – there are many applications of hydrogen that do not require fuel cells, and many fuel cells that do not operate on hydrogen fuels. Nevertheless, their combination allows an efficient and emission-free supply of energy to many applications, namely vehicles, so they are often pooled together – as in this programme.

Programme Structure

The courses we offer in the CPD programme are all tailored for delivery to working staff in industry and institutions, i.e. take into consideration that time is constrained. They therefore stretch out over 4 to 5 weeks with tutorials on Friday afternoons taking place each week. All teaching material is based on the modules we also run for the MSc programme. You will therefore partake in cutting edge information offered at a high professional level. The specialisation level corresponds to Masters and PhD studies students, equivalent to participants from industry having a university degree in STEM subjects and/or a number of years of professional experience (not necessarily in fuel cell and hydrogen technologies, though, otherwise you would not be here).

We have selected 5 modules for the Winter 2025 programme which will be described in more detail in the following. You can select a single course, or several, depending on your training needs and the time you can afford to follow a course.

Weekly timetable

The timetable of all modules can be found on the next pages of this handbook.

All modules (courses) start off with an Induction Tutorial on a Monday morning. We then hold tutorials with Q&A sessions, exercises, and additional material on every Friday afternoon. When two (or more) modules run in parallel, these tutorials will be staged, i.e. not running at the same times, so you can (theoretically) follow several modules in parallel.

A Final Tutorial is meant to wrap up things after generally 4 weeks, and also gather feedback. You will, though, retain access to the Canvas course beyond the end of the tutorial series in order to do further reading, flip back to revise and re-read material, or simply revisit to freshen your understanding.

You can theoretically join a course at any time, though a late start will deprive you of the opportunity to attend all tutorials and get your questions answered. All teaching material is available on Canvas and can be consulted at any time. We will run Induction Sessions for late arrivals, prior to the weekly Friday tutorials, as necessary.

Teaching Delivery

All modules are delivered online via the University online CANVAS Learning Management System (LMS). Lectures have been pre-recorded and you can watch them in leisure at your own pace. Every lecture is accompanied by the slide set, often with additional material, and a quiz to check on your understanding.

Ideally, you will have noted down questions before attending a tutorial, so you can then discuss any issues in understanding with the lecturers. In this way we allow you to access material when it best suits you (within the constraints of the timetable), you can manage your time, and concentrate on discussing open questions, further issues, new ideas etc. during the tutorial interactions, making best use of the availability of staff.

While first access to material will only occur after the Induction Tutorial, you can always go backwards and re-visit material. You will retain access until the end of your enrolment at UoB, which only occurs a few months after joining the course.

Assessment

You need not take part in the module assessment.

If you do, though, you can obtain educational credits, with some of the every modules carrying 10 (UK) credits (equivalent to 5 ECTS points in the EU). With this system of ‘microcredentials’ you can collect credits over a given period of time, and once having reached 120 credits (i.e. followed 12 courses), register for a Masters’ research project at a university recognising your credits (e.g. UoB) in order to obtain an MSc degree. If you are interested in this option, please contact the university or module leads for more information. Terms and conditions apply (e.g. referring to the

period over which you can ‘collect’ credits, and the subjects you can or need to collect for a specific university degree).

Assessment will generally consist of class tests and coursework. Class tests are sat online during a specific time window (ranging from 1 hour to a whole morning or afternoon), generally with one hour to complete. Coursework will mostly be a report in the range of 2,500 to 5,000 words (around 10 to 15 pages). Class tests will generally be sat during the last week of the module, with the coursework to be typically delivered one or two weeks later.

Module Structure

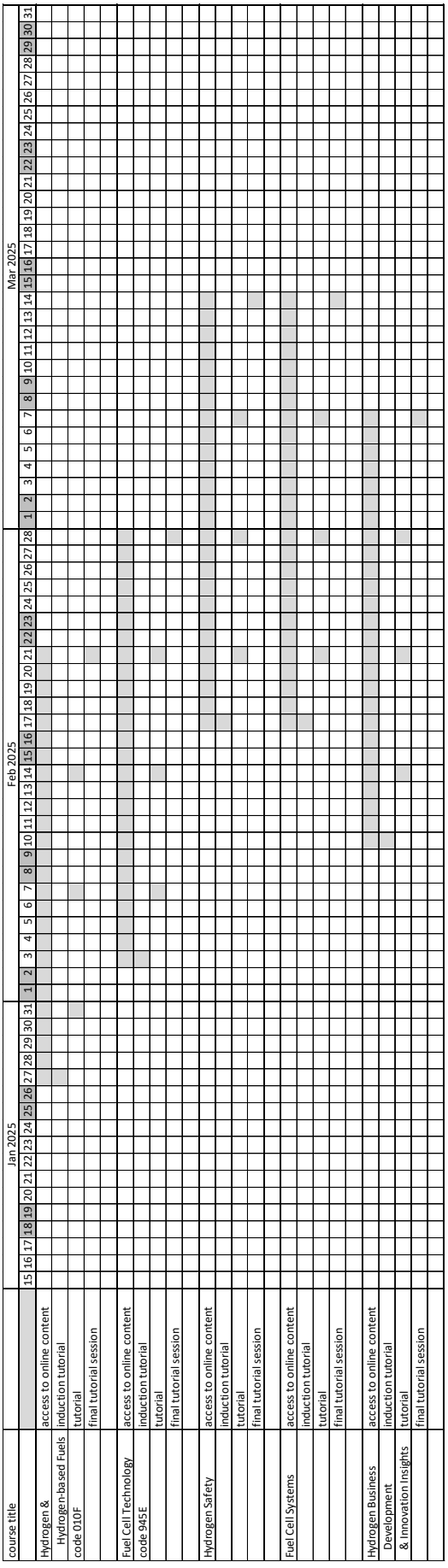
All modules have an introductory section with basic information, the timetable etc.

This is followed by four to five ‘Units’ collecting lecture topics under a joint matching umbrella. The Units roughly correspond to the amount of material you should be viewing and digesting within a week.

The last Unit will generally collect the recordings of tutorial sessions for re-visiting.

In the following we will present the details of the four modules for your reference.

Timetable Winter 2025



Module Specifications

Hydrogen and Hydrogen-based Fuels

HHF, module code 010F

The module covers the production and storage of hydrogen as a fuel for fuel cells and for decarbonising industry and the overall energy system. The topics covered include:

- An Introduction to Hydrogen
- Hydrogen production from fossil energy sources
- Hydrogen production by the electrolysis of water at low and high temperatures
- Hydrogen production using nuclear energy and solar thermo-chemical cycles
- Renewable hydrogen, non-electrolysis and natural (geologic) hydrogen
- Separation and Purification of Hydrogen
- Hydrogen Storage
- On-board storage
- Infrastructure, supply chain, transport, dispensing
- Power to Gas technologies

Learning Outcomes

By the end of the module participants should be able to:

- Present and criticise the methods, potential, benefits, and prospects of hydrogen production, storage and safety handling.
- Understand the principles relating to Power to Gas and Power to X concepts
- Describe the Physics, Chemistry and Engineering of hydrogen production and storage technologies and be able to apply this knowledge to moderately complex problems.
- Choose appropriate technology when faced with a moderately complex engineering design task.
- Communicate information, concepts, problems and solutions to specialists and non-specialists.

Credits	10 (to be obtained following assessment)
Method of assessment	50% class test, 50% coursework
Module lead	Dr. Artur Majewski

Fuel Cell Technology

FCT, module code 945E

Fuel Cells are a highly efficient technology to convert hydrogen, and a number of other fuels, into electricity and heat. They are employed in vehicles, for portable applications, uninterruptible power supply, off-grid energy supply, power generation etc. and are an important element of reducing greenhouse gas emissions and improving urban air quality. The conversion of hydrogen fuels results in an emission of water alone. The efficiency of fuel cells is in principle higher than that of thermal processes, which gives them another leading role in increasing the energy efficiency of global energy systems, helping to integrate renewable energies, and reducing the use of fossil energy sources.

The module covers fuel cell technologies and their science

- electrochemistry/thermodynamics/energy analysis tools,
- applications of fuel cells,
- low temperature fuel cells, materials, designs, fuels, and systems,
- high temperature fuel cells, materials, designs, fuels, and systems,
- fuel cell systems,
- fuels for fuel cells,
- hydrogen and fuel cell safety issues,
- environmental analysis, market introduction, economy, and policy framework.

Learning Outcomes

By the end of the module participants should be able to:

- Present and criticise the potential, benefits, boundary conditions, and prospects of employing fuel cell technology today and in future markets
- Describe the Physics, Chemistry and Engineering of fuel cell technologies and be able to apply this knowledge to moderately complex problems
- Be able to choose appropriate technology when faced with a moderately complex engineering design task
- Communicate information, concepts, problems and solutions to specialists and non-specialists.

Credits	10 (to be obtained following assessment)
Method of assessment	100% written coursework
Module lead	Prof Robert Steinberger-Wilckens
Module delivery	Steinberger-Wilckens & Team

Hydrogen Safety (H2S)

This module supplies basic knowledge necessary in assessing risks from operating fuel cell and/or hydrogen systems. It was developed in cooperation with UoB's strategic partner Bundesanstalt für Materialforschung, Berlin (BAM). Students will understand effects and learn how to mitigate and manage risks.

The topics covered in the module are:

- Introduction to hydrogen safety
- Hydrogen properties and hazards, comparison with other fuels
- Hydrogen safety engineering, laboratory codes of practice, safety precautions
- Handling hydrogen releases
- Hydrogen interaction with materials
- Case studies

Learning Outcomes

By the end of the module participants should be able to:

- Demonstrate knowledge related to hydrogen properties and hazards and ability to apply this knowledge to hydrogen safety engineering design, including compliance with regulations, codes and standards.
- Evaluate requirements for safety provisions by taking into consideration knowledge on hydrogen releases, ignition, laboratory codes and material properties.
- Assess issues and hazards of hydrogen handling as compared to other energy carriers and fuels.
- Give guidance to other professionals in tackling hydrogen safety problems.

Credits	n/a (currently under consideration)
Method of assessment	*class test 25%, individual hazard assessment 2,500 words 75% [to be confirmed]*
Module lead(s)	Dr Artur Majewski / Prof Robert Steinberger-Wilckens

Fuel Cell systems (FCS)

The module builds on knowledge of fuel cell stack functions and designs and should only be chosen based on prior experience or training in fuel cell technology.

The module supplies the principle and technical knowledge necessary to integrate fuel cell stacks (covered in modules Low and High Temperature Fuel Cells, O2 & O3 of the MSc programme Fuel Cells and Hydrogen Technologies) into fully functional system, mainly covering details of the Balance of Plant and integration and packaging issues.

This will include:

- air and fuel gas supply and processing
- heat exchangers,
- water and heat management
- electrical connection(s)

Learning Outcomes

By the end of the module participants should be able to:

- Present and explain in detail the components in fuel cell systems, the boundary conditions in setting their specifications, and their function.
- Describe the Physics, Chemistry and Engineering of fuel cell system components and be able to apply this knowledge to moderately complex engineering problems.
- Choose appropriate components when faced with a moderately complex engineering design task.
- Communicate information, concepts, problems and solutions to specialists and non-specialists.

Credits	n/a (currently under consideration)
Method of assessment	*individual engineering design study, 3000 words (65%), class test (35%) [to be confirmed]*
Module lead	Dr Yousif Al-Sagheer
Module delivery	Yousif Al-Sagheer & Team

Hydrogen Business Development and Innovation Insights (HBDII)

The course aims at the market of skills development in the field of hydrogen and industry decarbonisation; with the growth of this market sector a distinct lack of skilled staff has been noted by companies around the globe; the course aims at supplying participants with a broad overview of how business ideas are developed, businesses started and grown, and how creation of ideas and innovation can be managed.
These are all key skills required for building the hydrogen decarbonisation supply chains, but are also valid for other DeepTech sectors. As a 'hands-on' activity and exercise, participants will be shown how business plans are written and craft an outline of their own. The skills obtained will not only be key in establishing startups, spin-outs, and new businesses, but are equally valid for staff in management positions who are responsible for profit centres. They will likewise need to understand the business side of things when competing for resources within a company.

This will include:

- introduction to tools for spurring creativity and for ideation (creating business ideas),
- introduction to using online tools and AI to assess and validate business ideas,
- considerations in creating new businesses,
- finance and finance sources,
- intellectual property rights protection, and
- basics of business plan writing.

Learning Outcomes

By the end of the module participants should be able to:

- use the business canvas method to create and develop own commercialisation ideas,
- explain sources of finance for business development,
- establish an outline business plan, and
- assess whether and how IP can be protected.

Credits	n/a (currently under consideration)
Method of assessment	*individual business plan study, 3500 words [to be confirmed]*
Module leads	Dr Birgit Thoben/Prof Robert Steinberger-Wilckens

Administrative Arrangements

Finance and Fees

Unless notified otherwise, we charge

- £2,500 for participation in one course (standard charge),
- 50% discount are given for SMEs, employees of public bodies, university lecturers, and unemployed persons,
- students registered at a UK university pay £850.

For discounts on booking several modules, or enrolling several employees of the same company, please contact Prof Steinberger-Wilckens at r.steinbergerwilckens@bham.ac.uk.

Registering on a course

Please reach out to

Sarah Gomes at Loughborough University S.Gomes@lboro.ac.uk
for registrations via the HyDEX project.

or directly to Prof. Robert Steinberger-Wilckens in Birmingham at
r.steinbergerwilckens@bham.ac.uk

to receive the links and information to officially enroll on one of the courses.

General Data Protection Regulation & the Student Privacy Notice

The University of Birmingham needs to keep certain information about its employees, students and other users to allow it to monitor performance, achievements, and health and safety. It also needs to process information, for example so that staff can be recruited and paid, courses organised and also to ensure legal obligations to funding bodies and government are complied with. To comply with the law, information must be collected and used fairly, stored safely and not disclosed to any other person unlawfully. To do this, the University must comply with the Data Protection Principles set out in the General Data Protection Regulation (GDPR) and other data protection laws.