UNIVERSITY OF CAMBRIDGE
School of Technology

Technology Research Experience Placements (TREP) 2026 Project List

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Chemical Engineering & Biotechnology

CEB1: On the use of DRIFT and Raman spectroscopy to study the heterogeneous oxidation of hydrogen

Project Supervisor: Dr Ewa Marek

Department: Chemical Engineering & Biotechnology

Project Outline:

When hydrogen is burned in a fluidised bed, the heat capacity of solid particles reduces combustion temperatures to prevent nitrogen oxide emissions. The circulating particles promote temperature uniformity in the reactor. Fluidised bed combustion is therefore an emissions-free alternative to traditional gas flames. Combustion of hydrogen in such arrangements is characterised by a wealth of gas-solid reactions, where, in addition to radical recombination, surfaces can provide alternative oxidation pathways. However, detailed kinetic mechanisms for the oxidation of H_2/O_2 mediated on the surface of common bed materials, SiO_2 and Al_2O_3, are missing. In situ studies of surface reactions are proposed to elucidate the surface mechanism underlying heterogeneous oxidation.

In diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS), surface species with dipole moments (e.g. -OH in water) absorb incident radiation, allowing the identification of adsorbed species and surface functional groups. The transient evolution of hydroxyl species on particle surfaces can be studied, exposing particles to H_2 and O_2 at fixed or dynamic temperature conditions. Raman spectroscopy relies on inelastically scattered light by polarisable bonds (e.g. O-O in peroxides), providing complementary spectroscopic information to DRIFTS. Studies using Raman spectroscopy could reveal the role of peroxide species (H_2O_2) as a reactive intermediate during heterogeneous oxidation of hydrogen.

The combined use of DRIFT and Raman spectroscopy for in situ studies on surface-mediated oxidation pathways will reveal dominant pathways through which combustion may occur in the emulsion phase of a fluidised bed. Such mechanistic insights will be valuable for the development of chemical kinetic mechanisms for hydrogen combustion in fluidised beds.

Work environment: You will be working alongside 8 PhD students, 1 research fellow (JRF), 1 PDRA in Singapore. This is experimental work, so involves presence in the Department.

References: https://www.sciencedirect.com/science/article/pii/S1540748925000550

Prior experience/knowledge required: Capability to read scientific literature quickly, Matlab, Origin and/or Python.

Computer Science & Technology

CST1: Build a large language model and agents to solve the Abstraction and Reasoning Corpus Challenge

Project Supervisor: Dr Soumya Banerjee

Department: Computer Science & Technology

Project Outline:

Build a large language model and agents to solve the Abstraction and Reasoning Corpus (ARC) Challenge.

It has been suggested that large language models cannot reason. This project will infuse some reasoning/priors into large language models and apply them to a large reasoning corpus (Abstraction and Reasoning Corpus).

We will also build agents to solve the ARC-AGI 3.0 challenge.

We will also augment human performance with LLMs (by using a recent database of how humans solve ARC problems).

We will also apply large language models and large vision models/multimodal models to these problems.

For more information about the project please contact me.

References: https://github.com/fchollet/ARC

https://blog.jovian.ai/finishing-2nd-in-kaggles-abstraction-and-reasoning-challenge-24e59c07b50a

https://github.com/alejandrodemiquel/ARC_Kaggle

https://arcprize.org/arc-agi/3/

https://arxiv.org/pdf/2402.03507

Work Environment: In the Department of Computer Science & Technology.

Engineering

ENG1: Mechanics of 3D printed metals

Project Supervisor: Dr Matteo Seita

Department: Mechanics, Materials and Design, Department of Engineering

Project Outline:
One of the main drivers for the adoption of metal 3D printing technology-also known as additive manufacturing (AM)—is the ability to build parts with complex geometries. This paradigm has enabled the production of high-performance metal components with optimized strength-to-weight ratio, or with internal features for enhanced functionality. The disruptive potential of AM, however, goes beyond complexity of shape. Because materials are formed at the microscopic scale following a bottom-up manufacturing approach, AM offers the opportunity to make parts with complex "microstructure" (i.e., the ensemble of microscopic constituents that make up the material). Since the relationships between these complex microstructures and the resulting materials properties are difficult to unveil, this unique feature has yet to be capitalised on in current industrial applications. However, it may hold the key to designing the materials of tomorrow.

This project focuses on understanding the mechanical behaviour of different metal samples with different microstructures complexity using micro-mechanical tensile testing. The work will include microstructure analysis, nanoindentation, micromechanical testing, as well as data analysis. Pending equipment availability, the student may also be able to produce new samples with different microstructures using our custom-made metal 3D printer.

Work environment: You will be working alongside 3 PhD students and 3 postdocs. The work will be carried out in my own lab within the Department of Engineering.

References: https://www.sciencedirect.com/science/article/pii/S2214860420311817

Prior experience/knowledge required: knowledge of solid mechanics.

ENG2: Powder analysis for sustainable metal 3D printing

Project Supervisor: Dr Matteo Seita

Department: Mechanics, Materials and Design, Department of Engineering

Project Outline:

One of the features that would make powder-based additive manufacturing (AM) processes a more sustainable alternative to traditional metal production is the ability to recycle unused metal powders. In industry, however, unused powders are frequently exchanged for new ones to limit feedstock variability, which causes uncertainty over parts performance.

In this project, the student will use our powder analysis technique to assess reused powder degradation and devise computer vision algorithms to quantify powder variability. They will then install a bespoke powder analysis rig into a bespoke metal 3D printer and use it to develop in-line monitoring strategies to adjust— on the fly—the AM process to ensure the production of high-quality metal builds. This "smart" AM approach aims at improving the sustainability of metal AM processes by improving powder recyclability.

Work environment: You will be working alongside 3 PhD students and 3 postdocs. The work will be carried out in my own lab within the Department of Engineering.

References: https://www.sciencedirect.com/science/article/pii/S2214860422005164

Prior experience/knowledge required: Matlab/Python. Computer vision.

ENG3: Microstructure modelling during additive manufacturing processes

Project Supervisor: Dr Matteo Seita

Department: Mechanics, Materials and Design, Department of Engineering

Project Outline:

Attempts at using first principles physics to predict the results of additive manufacturing processes have largely failed. There are too many uncontrolled and uncontrollable variables to produce anything more than qualitative results. At present, it seems that only a finite element (FE) model that captures microstructure formation in fusion-based additive processes can be expected to correctly anticipate final microstructures (and thus properties). The creation of a model for these processes, such as laser powder bed fusion, will be a true science challenge and would represent cutting-edge technology.

In this project, the student will work with experimentalists and theorists in the group as well as with our industrial collaborators to devise a new FE model for predicting the microstructure of metal alloys produced by laser powder bed fusion.

Work environment: You will be working alongside 3 PhD students and 3 postdocs. The work will be carried out in my own lab within the Department of Engineering.

Prior experience/knowledge required: Abaqus or similar.

ENG4: How do green walls affect energy efficiency – data analysis project

Project Supervisor: Dr Rachel Thorley

Department: Civil Engineering, Department of Engineering

Project Outline:

Does growing plants on buildings make them more sustainable?

This data-based internship explores how vegetation such as ivy might influence building performance and energy efficiency. This project focuses on analysing and interpreting environmental data from sensors located inside and outside a building, examining how external conditions, such as weather, sunlight and seasonal change, affect internal thermal behaviour over time.

There is also potential to develop a web app to communicate findings and live data to the public and building users. The project also has the potential to link with an external research proposal on sustainable building design, with opportunities for your work to contribute to academic outputs, including a potential publication.

Project Goals/Learning outcomes

1. Analyse Building Performance in Relation to Weather:

Does growing plants on buildings make the building more sustainable? Work with real-world sensor datasets (temperature, sunlight, and external weather data) to understand how factors like shading, wall orientation and vegetation might influence heat transfer and energy efficiency.

2. Develop Data Visualisations:

Create clear, engaging visual outputs (graphs and dashboards) to communicate your findings. Potential to make an app to give live data updates for an interested student. These will help share insights with researchers and potentially the public.

3. Contribute to Sustainability Research:

Your findings may help inform wider discussions around nature-based solutions in the built environment. They could contribute to a live research proposal or future publication.

4. Outreach Opportunities:

There may be opportunities to help shape parts of the project into outreach activities and share them with sixth-formers, inspiring future researchers. Opportunity to work as part of a student team on an outreach residential for 1 week - experience in organising activities/project management/working in team.

References:

About greenery and building efficiency:
https://www.sciencedirect.com/science/article/abs/pii/S235271021930261X

Sensor data from Trinity College clock tower (example of data dashboard done elsewhere in university): https://clock.trin.cam.ac.uk/main.php

Work environment:

You would be working primarily with myself as a supervisor. I normally try and recruit several summer interns to form a small team. For this kind of data analysis project, I am flexible with working location, but they are very welcome to work at the Department, or at Churchill College where the sensors are located.

At Churchill, there would be opportunities to work with at the Bill Brown Creative Workshop. A brand new making and prototyping space that supports student creativity, design, and hands-on experimentation. Happy to support any opportunities you would like, and we can discuss to see how to make that happen!

In addition, we would look to link with Cambridge Zero's summer research intern network, which will provide opportunities for socialising and meeting new friends this summer.

Please reach out if you'd like to discuss the project; we look forward to hearing from you!

Prior experience/knowledge required: This project is open to students from any STEM discipline with an interest analysing large datasets, ideally using coding (e.g. Python, R or similar). An interest in climate or sustainability would be advantageous. Your exact subject background does not matter.

If you have an interest in software or web development, there is also scope to contribute to the development of a simple web app or interface for interacting with data from environmental logging devices. Curiosity, problem-solving and a willingness to learn are the most important things we are looking for.

ENG5: Robotics for Soil-Machine Interaction

Project Supervisor: Dr James Hambleton

Department: Civil Engineering, Department of Engineering

Project Outline:

The Terra-Robotics Laboratory in Cambridge is looking for a budding researcher who is excited about the idea of utilising robotics to manipulate complex materials (think autonomous terraforming). This summer project is open-ended and can go in many different directions depending on the interest of the student.

The Terra-Robotics Lab is in the Civil Engineering Structures Lab, with a setup designed to experiment with utilizing an industrial robot (ABB's IRB6400) to manipulate soils. It includes a vision system which is used to measure the terrain's current profile. The project supervisor/mentor is currently using the setup to evaluate methods for generating models of soil characteristics and interactions. The over-arching goal of the research is to develop semi-autonomous methods for evaluating soil properties to enable autonomous soil manipulation.

Some possible directions of the project are:

- Design of interesting robotic end-effectors for soil experiments
- Designing/programming of software for improved control and/or data acquisition
- Design of your own earth manipulation experiments
- Analysis of data from previously completed experiments
- Investigation into a more efficient perception system
- We are also welcoming project students with their own ideas.

This project is ideal for someone with an interest in multi-disciplinary robotics or soil-machine interaction—or someone who just wants to learn more!

Work environment: The group consists of one PhD student and the PI. The expectation will to be complete the research in the lab environment which is based in West Cambridge (Civil Engineering).

Prior experience/knowledge required: No particular background is needed! Although some coding skills will probably be useful no matter the direction the project goes. Some knowledge of geotechnics would also be useful, but also not required!

ENG6: Temporal Vagus Nerve markers of Metabolic Transitions during Glucose Clamp Experiments

Project Supervisor: Dr Amparo Güemes Gonzalez

Department: Electrical Engineering, Department of Engineering

Project Outline:

The vagus nerve is a key pathway linking peripheral metabolic organs and the central nervous system. Preliminary analyses from our previous work indicate that decreases in glucose, rather than absolute glucose concentration, are the primary driver of changes in vagus nerve activity. This suggests that vagal signals may encode metabolic stress or regulatory engagement rather than steady-state glycaemia. Glucose clamp experiments provide a unique opportunity to study vagus nerve responses under tightly controlled metabolic conditions. However, it remains unknown whether hypoglycaemic and hyperglycaemic states produce distinct temporal neural signatures, or whether vagus nerve activity reflects deviation from metabolic homeostasis regardless of direction.

Project Aim: To identify time-resolved vagus nerve electrophysiological markers associated with metabolic transitions and metabolic stress during controlled glucose clamp experiments in healthy animals.

Dataset: The student will work with an existing dataset acquired from healthy anaesthetised rats undergoing glucose clamp experiments. The dataset includes continuous vagus nerve electrophysiology recordings alongside precisely controlled hypoglycaemic, euglycaemic, and hyperglycaemic phases. All data will be provided in a curated, documented format at the start of the internship.

Research Questions:

1. Are changes in vagus nerve activity primarily driven by glucose shifts and metabolic transitions rather than absolute glucose levels?

2. Do hypoglycaemic and hyperglycaemic clamp phases exhibit distinct temporal vagal signatures, or shared markers of metabolic stress?

3. What is the temporal relationship between glucose transitions and the emergence of vagus nerve electrophysiological markers?

Methods:

The student will begin by familiarising themselves with the provided dataset and the physiological principles underlying glucose clamp methodology. Vagus nerve electrophysiology recordings will be pre-processed using established signal-processing pipelines, including filtering, artefact rejection, and segmentation into defined metabolic phases.

Quantitative features will be extracted from the neural signals, including time-domain measures, spectral power across frequency bands, and complexity-based metrics. Analyses will explicitly distinguish between absolute glucose level, direction of glucose change, and metabolic phase. Event-aligned analyses will be performed around clamp transitions to characterise the temporal evolution of vagus nerve markers during glucose changes, stabilisation periods, and recovery.

Results will be visualised using reproducible analysis workflows, and candidate temporal markers will be assessed for consistency across animals. The emphasis will be on identifying robust, interpretable neural signatures linked to metabolic transitions rather than static correlations.

Expected learning outcomes and skills development:

The student will gain hands-on experience in neural signal processing, time-series analysis, and feature extraction from electrophysiological data. They will develop an understanding of glucose clamp experiments and metabolic physiology, learn event-aligned analysis techniques, and build practical skills in Python programming, data handling, and scientific visualisation. The project will also develop critical thinking skills in hypothesis-driven biomedical research and interpretation of complex physiological datasets.

Expected deliverables:

- A structured report describing temporal vagus nerve markers associated with metabolic transitions
- Figures illustrating time-resolved vagus nerve dynamics during glucose changes and clamp phases
- Identification of candidate neural markers of metabolic stress
- Reusable analysis code to support future studies

References:

Guemes, A., Carnicer-Lombarte, A., Hilton, S., & Malliaras, G. (2023). A multivariate physiological model of vagus nerve signalling during metabolic challenges in anaesthetised rats for diabetes treatment. Journal of Neural Engineering, 20(5), 056033.

Malpica-Morales, A., Kalliadasis, S., Malliaras, G. G., & Güemes, A. (2025). Data-driven prediction of blood glucose dynamics from vagus nerve recordings using neural controlled differential equations. Machine Learning: Science and Technology, 6(3), 035062.

Work environment: The student will work under my direct supervision, with additional guidance from an MSc student conducting the glucose clamp experiments and a PhD student experienced in electrophysiological recordings. As the project is primarily computational, there is flexibility in the place of work. However, regular engagement will be required, including scheduled weekly meetings and ongoing communication to ensure steady progress and appropriate support.

Prior experience/knowledge required: Previous knowledge and experience with Python, introductory signal processing, and interest in physiology or biomedical engineering.