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MECHANICAL ENGINEERING PROJECTS

MECH22/1 High speed remote sensing system for turbulence measurements on the Great Barrier Reef

MECH22/2 Development of technology for marine cloud brightening

MECH22/3 The fluid mechanics of intranasal drug delivery-a pathway for the treatment of neurological disease

MECH22/4 Three-phase turbulent fluid mechanics

MECH22/5 Fibre-Optical Pressure Sensor Design by Finite Element Analysis

MECH22/6 Finite Element Analysis of a Piezo-Electric Photonic MEMS

MECH22/7 Opto-Electro-Mechanical Characterization of Photonic Microsystems

MECH22/8 Buoyant fires and their suppression by enhanced chemicals

MECH22/9 Combustion of Green Fuels (Hydrogen and its derivatives)

MECH22/10 Microstructural evolution along the build direction of a 17-4PH stainless steel fabricated by laser powder-bed fusion

MECH22/11 Mechanical behaviour of third-generation advanced steels

MECHATRONICS ENGINEERING PROJECTS

MECHATRON22/1 Open-source robotic vision with 4D light field cameras

MECHATRON22/2 Hyperspectral Imaging on Autonomous Underwater Vehicles

SPACE ENGINEERING PROJECT

SPACE22/1 Demonstration of an On-orbit Servicing Mission Using a Satellite Simulator
FACULTY OF ENGINEERING

BIOMEDICAL ENGINEERING PROJECTS

BME22/1 Automated Audio/Video-Based Lameness Characterisation in Athlete Horses
Supervisor: Dr Andre Kyme, collaborators at TeleMedVet (WA)

Eligibility: WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

Project Description:
The aim of this project is to develop and validate a deep neural network for audio/video-based equine lameness characterisation. This has the potential to dramatically improve the prediction of catastrophic injuries (e.g. fetlock fracture) in athlete horses. Current methods lack quantification, reliability and efficiency and require overhaul. Augmenting video and audio inputs into a comprehensive machine learning model is extremely novel, and nothing like this exists for gait analysis in horses. A neural network-based approach has many advantages—but there are also many unanswered research questions. The Winter Scholarship will tackle these questions.
This project is in collaboration with our imaging and veterinary partners at TeleMedVET, Perth, WA. The end goal is to develop a viable product that can be deployed throughout the athlete horse industry for game-changing injury prevention. The project will suit a student with an interest and strength in deep learning and its application to biomedical engineering.

Requirement to be on campus: Yes *dependent on government’s health advice

BME22/2 Micropatterning pluripotent stem cell differentiation
Supervisor: Prof Hala Zreiqat

Eligibility: Student that are pre-honors, or looking for research experience prior to a PhD

Project Description:
Human induced pluripotent stem cells (hiPSCs) can be differentiated into complex tissues in a dish. This project explores the use of 3D printed materials to control the differentiation of hiPSC derived tissue cultures.
You will learn how to use laser printing methods for micropattering stem cell differentiation, and then characterize the resulting tissues.

Requirement to be on campus: Yes *dependent on government’s health advice

BME22/3 Organ-on-a-chip for evaluation of nanotoxicity
Supervisors: Professor Ken-Tye Yong; Dr. Gurvinder Singh

Eligibility:
- Ability to conduct independent research activities.
- Excellent oral and written communication skills.
- Knowledge of/willingness to conduct wet-lab synthesis.
- Knowledge of/willingness to conduct cell culture.
- Ability to use CAD programs such as AutoCAD or SolidWorks.
- Knowledge of polymer chemistry and nanomaterials.
- Willingness of continuing as an honours project.
Project Description:
The animal trial is an inevitable process of drug development to assess its efficacy and toxicity prior to testing in human trials. The misfortune of sacrificing animals in countless failed trials is becoming a growing concern. With growing advocacy of complete replacement (1R) in animal testing and research, an alternative solution is urged. In recent years, organ-on-a-chip (OoC) is becoming an apparent solution to such a controversial ethical dilemma. Our group is working to advance the accuracy in predicting nanotoxicity and using OoC. In this project, we will design, fabricate, and evaluate a microfluidics design for cell culturing and nanotoxicity screening purposes. Continuation as an honours project is encouraged.

Requirement to be on campus: Yes *dependent on government’s health advice

BME22/4 Rapid detection of pathogenic bacteria
Supervisors: Professor Ken-Tye Yong; Dr. Gurvinder Singh

Eligibility:
- Ability to conduct independent research activities.
- Excellent oral and written communication skills.
- Knowledge of/willingness to conduct wet-lab synthesis.
- Knowledge of/willingness to conduct microbial culture.
- Basic knowledge of optics, chemistry or nanomaterials.
- Willingness of continuing as an honours project.

Project Description:
Pathogenic bacteria caused productivity loss is amounted to approximately more than US$95 million annually in the middle- to low-income countries. It is projected that premature death due to foodborne illnesses contribute approximately 420,000 cases of the total annual deaths worldwide. The full extent of the burden and cost of unsafe food is currently still unknown but its impact on global health, trade and development is likely to be profound. The surveillance and prevention of food risk and biological terrorism are of central importance all over the world. Therefore, food safety and public health become a global mission and need worldwide cooperation. In this project, we will build an optical microfiber sensor for straightforward sensing of common pathogenic bacteria such as Escherichia coli. The vision of this project is to develop a rapid, user-friendly, and low-cost detection method for pathogenic bacteria. Continuation as an honours project is encouraged.

Requirement to be on campus: Yes (dependent on government’s health advice)

BME22/5 Fluorescence coupled micropipette manipulation for investigating cell mechanosensing properties
Supervisors: Dr Lining Arnold Ju (ARC DECRA, NHF Future Leader Level 2, MIT TR35 innovator, Royal Society of NSW, The Edgeworth David Medal Award)

Eligibility:
Candidates with experiences in conducting experiments in a PC2 lab, having capability of using two or more following software: ImageJ, Micro Manager, LabVIEW, SOLIDWORKS, MATLAB are preferred; Preference is also given to applicants who have a strong interest in the research and treatment of cardiovascular and cerebrovascular diseases such as Heart attack and Stroke.

The anticipated outcome could translate into precision medicine design, bridging dependent medication strategies for individuals.

Project Description:
Blood clotting saves people from bleeding (hemostasis). The dark side of this process risks lives and leads to death (thrombosis). Dramatically, existing antithrombotic drugs are recognized as double-edged swords since they can cause bleeding disorders, and results are not always
promising. As a breakthrough of the bottleneck, recent studies demonstrate that the physiological function of these blood cells is closely intertwined with their response to mechanical cues.

Blood clotting saves people from bleeding (hemostasis). The dark side of this process risks lives and leads to death (thrombosis). Dramatically, existing antithrombotic drugs are recognized as double-edged swords since they can cause bleeding disorders, and results are not always promising. As a breakthrough of the bottleneck, recent studies demonstrate that the physiological function of these blood cells is closely intertwined with their response to mechanical cues.

Micropipette aspiration is widely used to mimic the compressive, tensile, and shear forces inside the human body to fulfill the knowledge of cell behaviors in a mechanical environment. In the School of Biomedical Engineering, we developed a robust live cell imaging platform integrating with a borosilicate glass micropipette to manipulate the cells. This project will use various shaped micropipettes to apply precisely controlled forces to the blood cells to benchmark the mechanosensing properties. By collaborating with researchers in the Charles Perkins Centre, we will correlate our findings in cell mechanobiology with existing cardiovascular disease to inspire new anti-thrombotic strategies.

Requirement to be on campus: Yes (dependent on government’s health advice)

BME22/6 Digital Single-Molecule Biophysics: Flow Molecular Dynamics simulation under shear condition for thrombosis and haemophilia study

Supervisors: Dr Lining Arnold Ju (ARC DECRA, NHF Future Leader Level 2, MIT TR35 innovator, Royal Society of NSW, The Edgeworth David Medal Award)

Eligibility: The capability of using two or more of Pymol, VMD, GROMACS, ANASYS, Comsol, Linux scripts, MATLAB, and other software. Preference is given to applicants who have a strong interest in researching and programming. The anticipated outcome could translate into the structural explanation of haemophilia inherited deficiency and assist the development of the novel ‘mechanodrugs’

Project Description:
Clotting and bleeding are two sides of a coin, leading to cardiovascular diseases such as stroke and haemophilia—the No.1 worldwide killer. It has long been recognised that the von Willebrand factor (VWF) is the mechanosensor for primary and secondary haemostasis by interacting with platelets and clotting factor VIII. We have recently discovered a new ‘biomechanical’ prothrombotic mechanism that highlights the remarkable VWF sensitivity to the shear stress of blood flow disturbance. Importantly, we found that the current drugs are often
not successful and come with an increased financial burden. To address this pressing need, we are establishing a GPU accelerated multi-scale simulation platform to unveil the effects of blood flow disturbance at the single-molecule level. For the first time, fluid mechanics and biochemistry fields will be united in silico to correlate the haemodynamic parameters with clotting and bleeding disorders.

Requirement to be on campus: Yes *dependent on government’s health advice

BME22/7 Novel Spheroid-Endothelium-on-chip model for tumour intravasation
Supervisors: Dr Lining Arnold Ju (ARC DECRA Fellow, Heart Foundation Future Leader Level 2, MIT Technology Review Innovator Under 35, Royal Society NSW Edgeworth Fellow)

Eligibility: Candidates with experiences in cell culture and tissue culture in PC2 lab are preferred; capability of using one or more of the softwares – ANSYS, Klayout, SolidWorks, AutoCAD or other design software. Preference given to applicants who have a strong interest in the research and treatment of cancer metastasis. The anticipated outcome could translate into point-of-care tools that facilitate physicians’ decisions on cancer diagnosis, follow disease progression and optimise cancer drug treatment courses.

Project Description:
Cancer metastasis accounts for 90% of cancer-related deaths in patients, and more importantly, it has been found that cancer patients have a 5- to 7-fold increased risk of developing vein thrombosis. During the metastasis processes, cancer cell intra and extravasation are the important events where tumour cell migrates through the vessel endothelial boundary. And this process involves tumour cell-vessel endothelium interactions. It was proposed that tumour cells can adjust their mechanical properties to facilitate extravasation, and the endothelial cells also have active instructive roles in the dissemination of cancer. So, it’s important to know whether how tumour cells invade into vessel, and whether mechanical stimuli could facilitate tumour intravasation.

To address this pressing need, we use tissue engineering and soft lithography to develop an endothelialised microfluidic platform that incorporates cancer spheroids to visualise cancer transendothelial migration and to understand the molecular event underlying the intravasation mechanism. We are assembling a team of bioengineers and clinicians at the Biomedical engineering new building J03, Sydney Nano Hub and Charles Perkin Centre.

Requirement to be on campus: Yes *dependent on government’s health advice
BME22/8  Predicting Human Brain states using Transformers
Supervisors: Dr Mariano Cabezas and Dr Jinglei Lv

Eligibility:
- Basic skills with programming. Python programming is preferable
- Basic knowledge about medical image.
- Self-motivation, curiosity about research and passion to succeed.

Project Description:
The human brain is a complex dynamic system with still many unknowns when it comes to its functional behaviour. However, functional MRI provides a means to record brain activity. The activity at a given time point can then be used to define a brain state. That begs an interesting research question, i.e., whether one brain state can predict following states. This biological question can be formulated as an auto-regression problem in machine learning. Recent deep learning techniques, specifically transformers, can learn patterns from high dimensional time series and can model the sequential relationship between states (also known as tokens). We aim to develop a transformer-based method to explore this research question. Furthermore, we could use this model trained on healthy brains to predict brain states of patients with pathology. Afterwards, the measured prediction error could be employed to find anomaly regions related to a specific disease. The Human Brain Connectome dataset will be used for model training and validation while patient data from OASIS, ADNI or PPMI will be used for the disease research part.

Requirement to be on campus: No

BME22/9 Exploring the world of cellular responses with image analysis and artificial intelligence algorithms
Supervisor: Dr Sandhya Clement

Eligibility: Only for students who have currently enrolled (S1 2022)/ previously completed (S1, 2021) BMET5933.

Project Description:
Artificial intelligence is considered to be a useful tool to explore and answer a range of cellular biology questions. Utilizing AI algorithm, one can develop a fundamental understanding of how cells respond to various stimulations and their potential therapeutic applications. The current project aims to develop a practical AI based image analysis algorithm for identification of the biologically significant parameters and stimulation based on cellular morphological changes, rate of division to name a few. The project is focussed on educating and training the students to implement the existing classroom-based knowledge to practical research experience. This project will enable the students to explore the synergies of the fundamentals of computation, software development and cellular responses.

The experience gained during the proposed project will enable the student to appreciate a multidisciplinary approach of answering research questions, and the development image analysis tools using powerful AI techniques.

Requirement to be on campus: No. (This project does not require any lab space. The student can work remotely using their laptop by running their python code using the online tool such as Google Colab/ Jupyter Notebook. The students will be working on the images that are either acquired as a part of the ongoing cancer research or on medical images that are publicly available).
BME22/10 Peripheral nerve blocking and stimulation  
**Supervisor:** Prof Alistair McEwan  

**Eligibility:** WAM>75 and should have completed >96 credit points at the time of application for UG students  

**Project Description:**  
Phantom pain in limb amputations, spasticity in neurological conditions and restoring a sensation in peripheral nerve damage would all benefit from a peripheral nerve interface. In this project physical and computer simulation of high frequency AC peripheral nerve blocking and selective multichannel current steering stimulation of the peripheral nerve using a range of cuff electrode designs and stimulation strategies will be performed. In particular the project will involve development of computational (Comsol or similar) models with appropriate tissue dielectric properties and realistic anatomy and in vitro 3D printed gel or cell-based models of peripheral nerves for electrode testing is needed ahead of in-vivo experiments.  

**Requirement to be on campus:** Yes *dependent on government’s health advice

BME22/11 Accessible Tech Toys for Infants with Significant Motor and Physical Needs  
**Supervisors:** Prof Alistair McEwan and Petra Karlsson  

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.  

**Project Description:**  
Play is important for children to learn important developmental skills through interactions with toys, parents, and other children. However, children with disability have difficulties in engaging in play due to limitations in their motor skills and are unable to handle and play with commercially available toys. There is a need to design and adapt toys and games for children with disability to allow them to participate in play.  

The aim of this project is to co-design and adapt toys to better meet the needs for children with cerebral palsy who cannot easily play with commercially available toys. These adapted toys will be developed and sent back to the families to evaluate their ability to engage children in play. This will be extremely beneficial to children with cerebral palsy as they will be able to engage children in play and to have fun, retain/improve motor function, and learn crucial developmental skills.  

**Requirement to be on campus:** Yes *dependent on government’s health advice

BME22/12 Performance Evaluation of Denoising Algorithms for PET/MR Imaging  
**Supervisors:** Dr Georgios Angelis  

**Eligibility:** Advanced programming skills (C/C++, Matlab, Python); Good mathematical background on linear algebra  

**Project Description:**  
Simultaneous PET/MR imaging allows the acquisition of functional and anatomical tomographic information at the same space and point in time. However, the quality of PET images is affected by lower spatial resolution and higher statistical noise, compared to their MR counterparts, due to several sources pertaining to data acquisition and image reconstruction.  

In this project, the performance of several image denoising algorithms, such as Total Variation, Non-Local Means and Block-matching with 3D filtering, will be evaluated. The hyper-parameters of each denoising method will be optimised for several clinically relevant noise...
levels and activity distributions. The quality and quantitative accuracy of the denoised reconstructed images will be assessed using simulated digital data, as well as a set of clinical [18F] FDG PET/MR brain data. This project is an exciting primer to medical image processing and analysis.

Requirement to be on campus: No

BME22/13 Electromechanical interaction of gold nanomaterials with human cardiac cells
Supervisor: Dr Gurvinder Singh

Eligibility: Nanomedicine/Nanotechnology

Project Description:
Excellent biocompatibility, electrical conductivity, and ease in the fabrication of plasmonic gold nanomaterials make them promising candidates for biomedical applications in regenerative medicine, specifically for the engineering of electroconductive tissues (cardiac or nerve) that can be used for the treatment of trauma, injuries, or diseases. However, there is a knowledge gap regarding mechanistic understanding about interactions between gold nanomaterials and electroactive human heart cells. The project aims to develop diverse geometries of gold nanomaterials and use 3-D hydrogel biomaterials that mimic a porous tissue microenvironment to independently study nanomaterial’s electrical and biophysical interaction of nanomaterials with cardiac cells at cellular and molecular levels. Specific goals or proposed research activities of the project include: i) fabrication of gold nanomaterials with a wide range of geometries and defined surface chemistries using our well established protocols and integrate them in hydrogel-based scaffolding biomaterials; ii) cellular uptake of gold nanoparticles, surface colonization, spreading as well as changes cytoskeletal structure of cardiac cells, and iii) selecting nanomaterials of fixed geometry with varying surface functionalities to specifically isolate the effect of varying conductivity of nanomaterials on the electrophysiological response of cardiac cells.

Requirement to be on campus: Yes *dependent on government’s health advice

CHEMICAL AND BIOMOLECULAR ENGINEERING PROJECTS

CBE22/1 Computational modelling of a heart valve using LS-DYNA
Supervisor: Prof David Fletcher

Eligibility: Need to have a strong interest in mathematics, computer simulations and the ability to program in a computer language, preferably python.

Project Description:
As part of a multi-year, multi-disciplinary project to develop replacement heart valves for children the team are creating novel designs and materials. One aspect of the work is performing numerical simulation of the flow and structural response of the valve. We are already obtaining interesting results and need to run more cases and improve automation. This project will teach computer simulation and will involve programming in Python, with a view to creating/improving workflows and analysis scripts. There will also be ample opportunity to interact with the experimental team and contribute ideas on how the valves/simulations can be improved. You will be working at the leading edge of computer simulation.

Requirement to be on campus: Yes (Flexibility to work remotely via internet but will have some face-to-face meetings (conditions permitting).
CBE22/2 Production of liquid fuels from carbon dioxide
Supervisor: Dr Fengwang Li
Eligibility: Experience in the following subjects would be advantageous: Chemistry, Chemical Engineering, Materials Science and Technology

Project Description:
Formic acid is widely accepted as a promising liquid fuel for directly formic acid fuel cells or as a hydrogen carrier, both being clean technologies enabling a sustainable future. Current fossil fuel driven chemical industry and transport emit significant amount of CO2, a greenhouse gas that causes climate changes. Why not converting waste CO2 to valuable formic acid for clean use? This project aims to discovery catalyst materials that can drive the conversion of CO2 to formic acid using electricity as a power input and can work at room temperature and ambient pressure. This electricity-driven CO2-to-formic acid is distinct from the current chemical industry where high pressure and high temperature are oftentimes used and fossil fuels are required as feedstock or power.

Requirement to be on campus: Yes *dependent on government’s health advice

CBE22/3 Design, discovery, and development of Metal-organic framework-based biocatalysts
Supervisors: Dr. Weibin Liang and Prof. Jun Huang

Eligibility:
- Some background in Chemical engineering, chemistry, catalysis or equivalent
- Knowledge background in enzyme and/or biochemistry will be preferred
- The ability to work well with others in a team
- Excellent oral and written communication skills

Project Description:
Biocatalysis presents a significant opportunity in chemical manufacturing, due to its efficiency, selectivity, and environmental sustainability. However, the activity of many biocatalysts is compromised, or extinguished, when exposed to thermal, pH, and/or chemical stressors. This is largely due to the structural fragility of biocatalyst (e.g. enzymes) in artificial conditions. This project aims to stabilize biocatalyst in/or metal-organic frameworks (MOFs), generating a stable MOF biocatalyst with high reaction–activity and chemo-selectivity in catalysing reaction of industrial importance.

This project involves the synthesis, characterization, and catalytic application of biocatalyst immobilized in/on metal-organic frameworks (MOFs). The student will assist in the synthesis and characterization of the MOF biocatalyst, as well as testing the catalytic performance of the materials.

Requirement to be on campus: Yes *dependent on government’s health advice

CBE22/4 Design of Metal-organic Framework solid-acid catalysts for biomass transformation
Supervisors: Dr. Weibin Liang and Prof. Jun Huang

Eligibility:
- Some background in Chemical engineering, chemistry, catalysis or equivalent
- The ability to work well with others in a team
- Excellent oral and written communication skills

Project Description:
Recently, the synthesis and application of metal-organic framework (MOF) based solid acid catalyst has attracted wide attention in scientific and engineering aspects. This project aims to
design and synthesize a series of MOF-based solid acid catalyst in the application of biomass transformation. This project will include a literature review on recent advancements in MOF-based solid acid catalyst. The student will also be involved in the synthesis and characterization of MOF materials, as well as their catalytic performance testing.

**Requirement to be on campus:** Yes *depending on government's health advice

### CBE22/5 Novel lead-free perovskite quantum dots catalysts for artificial photosynthesis of green fuels from CO$_2$ reduction

**Supervisors:** Prof. Jun Huang, Dr. Rui Tang

**Eligibility:**

To be eligible, the candidate should

- have basic knowledge background in either of the following: chemistry, chemical engineering, material engineering, and biomedical engineering.
- basic knowledge of semiconductors will be preferable.
- passion for pursuing research in renewable energy.

**Project Description:**

Over the past decade, achieving sustainable CO$_2$ recycling with renewable sunlight as the energy source has been viewed as crucial to meet the rising global warming issues. With Australia receiving the highest solar radiation globally, artificial photosynthesis offers an opportunity to direct convert CO$_2$ into usable chemical energy (i.e. CO, CH$_4$). Although great progress has been realized in the photocatalytic CO$_2$ reduction reactions (CO$_2$RR) fields, the photo-induced carrier generation/transfer and surface reaction kinetics of catalysts still restrict its practical application. Considering thermodynamic and kinetics issues during the CO$_2$RR process, it is of great urgency to find novel catalysts with efficient carrier generation/transfer.

This project aims to design a high-performance perovskite photocatalyst with defect engineering to realize selective photocatalytic CO$_2$RR. By tailoring the surface chemical states and semiconductor properties of the photocatalyst to invoke flexibility to control the photocatalytic CO$_2$RR performance of the catalyst system.

**Requirement to be on campus:** Yes *depending on government's health advice

### CBE22/6 Understanding the Effects of Membrane Pore Size and Surface Chemistry for Polymer Confinement and Gas Separation

**Supervisors:** Dr David Wang and Yi-Chen-Lin

**Eligibility:**

- Must achieve WAM 75 or higher
- Possess a general understanding and interest for membrane separations.

**Project Description:**

Organic polymer membranes are widely used for gas separation that operates at low pressures and temperatures, but their performance is usually defined by the empirical trade-off between gas permeability and selectivity. Recently, we reported a novel inorganic/organic polymeric interfacial diffusion membrane, which delivers an extremely high selectivity for gas separation and far exceeded the Robeson boundary. Selective molecular transport proceeded only in the amorphous polymer interface between the alumina support and the polymer crystals, of which is intricately linked with the phenomenon of nanoconfined crystallization. Hence, the ability to control nanoconfined crystallization of polymer is essential for a high-performance gas separation membrane. In this project, polymer-support intermixed membrane will be prepared on the Al$_2$O$_3$ disk supports, and sol-gel method will be employed to change the pore size, porosity and interfacial chemistry of the supports. Then polyetherimide will be infiltrated into the modified supports to create the inorganic/organic
polymeric interfacial diffusion membranes. Gas separation tests of the final membranes will be carried out to understand the behaviour of polymer confinement.

**Requirement to be on campus:** Yes *dependent on government’s health advice

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**CBE22/7 Magnetism assisted electrochemical H2O2 production**

**Supervisor:** Dr Li Wei

**Eligibility:** Yr3/4 and MPE students with chemistry background

**Project Description:**

H$_2$O$_2$ is an essential chemical that can be directly used as disinfectant and green oxidants. Electrochemical H$_2$O$_2$ synthesis can replace the energy and emission-intensive anthraquinone process but requires efficient catalysts and electrolysers. This project aims at investigating a new approach to enhance the performance of a promising catalyst demonstrated recently in our group. Without involving complicated chemical synthesis and high-temperature annealing, we will probe the opportunity of using magnetic fields to tune the catalyst properties and enhance the catalyst electrochemical activity. The impact of magnetic field properties, e.g., strength and direction, on the catalyst performance will be obtained. The origin of the performance enhancement will be further investigated by catalyst property characterisation and computation studies.

**Requirement to be on campus:** Yes *dependent on government’s health advice

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**CBE22/8 Polymer-based sensors for biomedical applications**

**Supervisors:** Prof. Fariba Dehghani, Dr. Sina Naficy and Dr. Syamak Farajikhah

**Eligibility:** Previous lab work experience will be an advantage.

**Project Description:**

Recently, flexible, and wearable sensors emerged as a new class of personalised point of care (POC) systems to provide real-time monitoring of an individual’s physiological biomarkers. These sensors are also great candidates for the potential applications in electronic skin, wearable electronic systems, soft robotics, and noncontact sensation. This project will focus on the design and fabrication of cost-effective flexible polymer-based sensors for biomedical applications. Stimuli-responsive composites with tunable functionalities will be designed and used for detection of a range of analytes, e.g., humidity, ammonia, pH, etc. Concentration of the functional fillers, ionic compounds, and initial electrical resistivity will be optimised to get the best sensor performance. These sensors will be fabricated using different techniques, e.g., casting, fibre spinning and 3D printing, and their reproducibility, accuracy and response time will be evaluated. Finally, their sensing performance and reliability in a simulated environment will be evaluated.

**Requirement to be on campus:** Yes *dependent on government’s health advice

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**CBE22/9 Design Functional Nanomaterials on Prostate Cancer Cells**

**Supervisor:** Prof Jun Huang

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**

Cancer is one of the leading causes of death worldwide, and few medicines cure cancers. There is an urgent demand for effective anti-cancer therapies with few side effects. Numerous dietary substances have been studied on their effectiveness in suppressing cancer. As one of the most extensively studied category, oligomeric proanthocyanidins (OPC) have shown a
strong potential to inhibit growth of cancer cells. However, the clinical use of proanthocyanidins is limited by its severe adverse effects, poor absorption, instability, bioavailability, and fast removal from the systemic circulation. It is known that nanomaterials are an excellent carrier for drug delivery. To examine whether nanomaterials can increase the potency of OPCs in suppressing cancer when used together, nano formulated OPCs loaded onto biocompatible and biostable materials will be tested on cultured prostate cancer cells.

**Requirement to be on campus:** Yes *dependent on government’s health advice

**CBE22/10 Personalised Polymeric Heart Valve Fabrication**

**Supervisors:** Dr. Sina Naficy, Dr. Syamak Farajikhah, Prof. Fariba Dehghani

**Eligibility:** We are looking for highly motivated and innovative team members. Some prior experience of working in the lab is preferable.

**Project Description:**
Congenital heart disease is surprisingly common, affecting almost 1 in 100 babies born. At least a third of patients born with CHD will require one or more major open-heart operations. For some, repeat surgeries are a necessary part of managing the condition. It is estimated that in Australia, around 50 children are born with this condition every year needing multiple operations. Each operation is highly stressful for the patient and families, as well as being very resource intensive. We aim to significantly reduce the number of operations for RV-PA conduit replacement by creating patient-specific polymeric heart valves that accommodate patient growth via innovative spatial and anatomic valve designs.

In this exciting project you will use advanced manufacturing techniques to create artificial heart valve prototypes from real heart valve images taken via CT scan for testing in a machine replicating heart movement.

If you are highly motivated, long-term placements are possible.

**Requirement to be on campus:** Yes *dependent on government’s health advice

**CIVIL ENGINEERING PROJECTS**

**CIVIL22/1 Augmented reality for supporting design and visualisation of buildings and bridges**

**Supervisor:** A/Prof Daniel Dias-da-Costa

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
Exploration of new tools for the support of advanced teaching and design experience. These could include BIM in combination with augmented reality. A strong curiosity and interest in learning coding/computational skills would be recommended. This project is at the forefront of technology and could provide a competitive edge for a recent graduate.

**Requirement to be on campus:** No

**CIVIL22/2 3D printing technologies for development of innovative solutions in the construction industry**

**Supervisor:** A/Prof Daniel Dias-da-Costa

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.
**Project Description:**
This project will explore different possibilities of using 3D printing technologies for enhancing the construction industry. The candidate will have the freedom to propose and explore new concepts and ideas, for example, based on auxetic materials to achieve enhanced performance. Interestingly, auxetic materials can increase their size/volume when loaded in compression, which is an unexpected and instrumental behaviour for high-end structural applications. This project will include a literature review on recent advancements and the exploration of ideas through computational mechanics and possibly small testing.

**Requirement to be on campus:** No

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**CIVIL22/3 Development of an extended finite element method for simulation failure analysis of materials and structures**

**Supervisor:** A/Prof Daniel Dias-da-Costa

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
This project is at the forefront of the computational mechanics of fracture propagation and failure analysis. The accurate simulation of fracture is of interest to many fields of research and industry design. This includes civil engineering applications and medical and mechanical, as long as there are brittle materials where fracture can develop and/or interfaces between materials along which fractures can develop. The interested candidate will develop new modelling skills and develop a small code to simulate the interfacial crack stresses in a benchmark problem. If successful, this project could serve as a pilot for developing a publication in an international journal with the team members. The skills developed by the candidate are sought after by the industry and can quickly become an essential asset for future job applications.

**Requirement to be on campus:** No

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**CIVIL22/4 Strengthening of composite cementitious materials using carbon polymers and state-of-the-art machine learning**

**Supervisor:** A/Prof Daniel Dias-da-Costa

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
Many existing structures are approaching the end of their service life. As such, innovative solutions are being sought to upgrade them for further use. This may require the development of strengthening techniques, for example, based on carbon polymers, that can quickly establish the necessary strength and serviceability. This project will explore advanced optimisation and machine learning to achieve the best possible performance of structures.

**Requirement to be on campus:** No

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**CIVIL22/5 Structural application of recycled fibre reinforced polymer (rFRP) composites**

**Supervisor:** Dr Ali Hadigheh

**Eligibility:** Basic knowledge about composite materials

**Project Description:**
Carbon fibre reinforced polymer (CFRP) composites are being increasingly used in lightweight structures due to their unique combination of high strength and low weight. These superior properties promoted high usage growth rates observed in aerospace, defence, construction, automotive and renewable energy. This research will aim to produce recycled composites for structural applications.

Requirement to be on campus: Yes *dependent on government's health advice

**CIVIL22/6 Service life prediction of infrastructures with machine learning**

**Supervisor:** Dr Ali Hadigheh

**Eligibility:** Basic knowledge of programming

**Project Description:**
Structures are subject to gradual and progressive deterioration over time, and are likewise prone to damage due to accident, misuse or extreme natural events. The on-going requirement for more structurally sound infrastructures has driven the introduction and development of advanced machine learning methods for structural health monitoring. This project aims to use machine learning methods for automated condition assessment and evaluation of infrastructure.

Requirement to be on campus: No

**CIVIL22/7 Continuous structural health monitoring of bridges using advanced fibre optics**

**Supervisor:** Dr Ali Hadigheh

**Eligibility:** Basic knowledge of programming and bridge design

**Project Description:**
This project will aim to apply fibre optics for structural health monitoring of a pedestrian post tensioned concrete bridge.

Requirement to be on campus: No

**CIVIL22/8 Passive building technologies for energy efficiency**

**Supervisor:** Prof Chengwang Lei

**Eligibility:** Applicants should have completed a medium level fluid mechanics course and understand thermodynamics and heat transfer.

**Project Description:**
Buildings consume a significant portion of the world-wide energy supply, and the energy consumed in buildings is mainly for maintaining thermal comfort for occupants via HVAC (heating, ventilation and air-conditioning). Many passive technologies have been developed to reduce energy consumption in buildings. For instance, solar chimney, which relies solely on the thermal energy from the sun to drive air flow through an air channel, has been adopted to promote natural ventilation; and water wall and phase change materials may be adopted to store solar thermal energy during the day and release the stored energy at night for heating. By optimising the designs of individual strategies and properly integrating them into buildings, optimal thermal comfort and maximum energy efficiency may be achieved.

The purpose of this winter vacation project is to analyse the performance of different solar chimney designs for multi-storey buildings.

Requirement to be on campus: No
CIVIL22/9 Soil quality and contaminations

Supervisors: A/Prof Federico Maggi, Dr Fiona Tang (U New England), Prof Budiman Minasny (U Sydney, Sydney Institute of Agriculture)

Eligibility:
- Basic knowledge of or willingness to learn hydrology and soil sciences; Good knowledge of MATLAB;
- Current knowledge of or willingness to learn high-performance computing (HPC) methods;
- Intermediate level of programming skills.

Project Description:
Soil is exposed to many sources of potential contaminations. Some of these have natural origin including some mineral-associated metals such as arsenic, while other are anthropogenic, that is, the result of leak into the environment of materials of synthesis not naturally occurring such as some chemicals. For these projects, we will focus on two important types of chemicals widely used in agriculture, fertilizers, and pesticides. These are used at extraordinary amounts every year: N and P fertilizers reach about 100 Tg-N/year and 50 Tg-P/year, respectively, while pesticides are used in excess of 4 Tg/year. The questions you will investigate will revolve around: How much of these will stay in the environment or will be degraded? In which ecosystem will these be accumulated? For how long will these substances stay there? And similar.

Requirement to be on campus: Yes *dependent on government’s health advice

ELECTRICAL AND INFORMATION ENGINEERING PROJECTS

EIE22/1 Capacitive wireless power transfer for bio-implantable and underwater devices

Supervisor: Prof Joe Zhu

Eligibility:
- Bachelor’s degree in electrical engineering
- Outstanding transcript (WAM>75)
- Good knowledge of AI and data analytics
- Skilful with MATLAB/Simulink/Python programming
- Research experience with publication record in electrical engineering (preferred)

Project Description:
Inductive wireless power transfer has been widely employed for power supply to various devices and systems, including bio-implanted devices, such as heart pacemaker and artificial hearts, and other applications, like mobile phone charger, and EV charging. However, the transmitting and receiving coils must be well aligned in order to achieve good transmission effects. Also, when the high frequency electromagnetic power is transmitted wirelessly through a lossy media, the power loss can be significant, resulting in low power efficiency. This project aims to develop an alternate wireless power transfer method based on the capacitive coupling mechanism to achieve high efficiency power transfer for bio-implantable and underwater devices. The project work includes the study of electric coupling principle, numerical electric field analysis, and electronic circuit analysis and design.

Requirement to be on campus: No
EIE22/2  A high sensitivity probe for remote detection of active ac power cables  
Supervisor: Prof Joe Zhu

Eligibility:  
- Bachelor’s degree in electrical engineering  
- Outstanding transcript (WAM>75)  
- Good knowledge of AI and data analytics  
- Skilful with MATLAB/Simulink/Python programming  
- Research experience with publication record in electrical engineering (preferred)

Project Description:  
Active ac power cables can be dangerous when the conductors are exposed. This project aims to design a high sensitivity probe for remote detection of active ac power cables. The project work includes a comprehensive study of detecting principles, probe materials, and feasible structures of the probe through a thorough literature, comparative study and design exercise. The feasibility can be demonstrated by analytical calculation and/or numerical simulation of the probe performance.

Requirement to be on campus: No

EIE22/3 Machine Learning aided Error-Control Coding  
Supervisors: Dr. Vera Miloslavskaya; Prof. Branka Vucetic

Eligibility: Interest in machine learning, software development skills (Matlab, Python or C++), good English skills (reading, listening, speaking and writing)

Project Description:  
Error-control coding is one of the key enabling technologies for reliable data transmission. For example, 5G employs the low-density parity-check (LDPC) and polar codes, while 3G and 4G rely on the turbo codes. Advanced error-coding techniques are ought to be developed to meet the stringent requirements of 6G. In this project, a student will have the opportunity to improve the reliability of data transmission by fine-tuning the bias function of the sequential decoder using machine learning (ML) techniques. Compared to analytical methods for the bias function computation, the ML techniques are expected to capture additional information about the error-control code structure and received noisy vector.

Requirement to be on Campus: No

EIE22/4 Machine learning in wireless networked control for Industrial Internet of Things  
Supervisors: Dr Wanchun Liu and Prof. Yonghui Li

Eligibility:  
- Background in mathematics, telecommunications or control.  
- Python programming  
- Experience in machine learning frameworks, TensorFlow, PyTorch or Matlab.

Project Description:  
Different from the 1st to the 5th generation (5G) of cellular communications, which are communications performance-focused, a primary driver behind 6G is the imminent deployment of Connected Robotics and Autonomous Systems (CRAS). To make CRAS come true, advanced wireless networked control technology needs to be developed. In particular, communications and control codesign will be a crucial research topic. This project will develop a novel deep reinforcement learning-based algorithm for communications and control codesign to achieve high-performance networked control.
Requirement to be on campus: Yes *dependent on government’s health advice

EIE22/5 Wireless human-machine collaboration
Supervisors: Dr Wanchun Liu and Prof. Yonghui Li

Eligibility:
- Background in telecommunications, control, robotics, or software engineering.
- Experience in Python programming
- Experience in machine learning frameworks, TensorFlow, PyTorch or Matlab

Project Description:
Wireless human-machine collaboration (HMC) will play a central role in a wide range of applications in the incoming industrial revolution that need humans to connect and collaborate with many machines remotely in real-time for completing a common goal. This requires seamless integrating of wireless human-control loop and automated-control loop. The project aims to establish the mathematical model of wireless HMC, optimise the system for achieving the best performance for control task completion, and develop a wireless HMC prototype.

Requirement to be on campus: Yes *dependent on government’s health advice

EIE22/6 AI-based Robotics
Supervisors: Dr Wanchun Liu and Prof. Yonghui Li

Eligibility:
- Background in telecommunications, control, robotics, or software engineering.
- Experience in Python programming
- Experience in machine learning frameworks, TensorFlow, PyTorch or Matlab.

Project Description:
Over the next decade, the biggest generator of data is expected to be devices that sense and control the physical world. The explosion of real-time data that is emerging from the physical world enables AI-based robotics for solving real-world control problems. The project will focus on developing AI-based computer vision and robot control methods to make robot arms complete different real-world tasks intelligently, such as pick-and-place in warehouse automation and waste sorting in waste management centres.

Requirement to be on campus: Yes *dependent on government’s health advice

EIE22/7 Hybrid learning-based Predictive planner and control for an emergency evacuation robot
Supervisors: Prof. Yonghui Li, Subhan Khan

Eligibility:
Basic Knowledge of Autonomous Systems and Python or MATLAB

Project Description:
Autonomous vehicles can be used for performing evacuations, particularly for assisting disabled people; in addition, they can be used for moving animals and goods. In those cases, the platform must deal with partially known infrastructure and other characteristics of the context, including dynamic obstacles. The destination may not be unique, as multiple safe destinations may be feasible. Therefore, this project will deal the path planning and control aspect under the evacuation scenario. First, a hybrid learning-based predictive planner will be designed to propose an efficient and optimal path for the robot. Second, a low-level control
will be designed to track the proposed path from the planner. Finally, simulations will be carried out using robot operating system (ROS) and Gazebo.

**Requirement to be on campus:** No

**EIE22/8 A High-precision Indoor Localization System Using WiFi RTT and IMU Fusion**  
**Supervisor:** Prof Yonghui Li

**Eligibility:**
- Programming skill (e.g., JAVA, Python, Matlab)
- Fundamental of machine learning and signal processing knowledge
- Fundamental of wireless and network knowledge
- Problem solving skill
- Strong teamwork skill.

**Project Description:**
This project aims to develop a high-precision indoor localization system (ILS) based on WiFi round trip time (RTT) and smartphone inertial measurement unit (IMU) fusion algorithm. WiFi RTT, a new WiFi protocol, IEEE 802.11mc, enables distance estimation between the WiFi access point (AP) and the smartphone based on the RTT fine time measurement (FTM). Meanwhile, the accuracy of positioning can be enhanced by IMU data from the device with the developed fusion algorithm. In addition, the fusion algorithm will be developed based on deep learning algorithms, and its performance will be compared with the traditional trilateration algorithm. An Android application with a graphical user interface (GUI) will be designed to demonstrate the developed ILS with both locations of WiFi access points (APs) and target device. The proposed ILS can be applied in various scenarios (e.g., factory, mall, office, etc.). The proposed ILS is planned to be evaluated in an indoor environment in both LoS and NLoS conditions. The proposed ILS is able to achieve centimeter-level accuracy at a low cost.

**Requirement to be on campus:** Yes *dependent on government’s health advice

**EIE22/9 Low precision neural networks**  
**Supervisor:** Prof Philip Leong

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
Low precision arithmetic can be used to reduce resource utilisation and improve the performance of edge-based neural network implementations. We are working on low-precision training and have achieved state of the art results [https://phwl.org/assets/papers/bm_iclr21.pdf](https://phwl.org/assets/papers/bm_iclr21.pdf). The aim of this project is to use NAS ([https://en.wikipedia.org/wiki/Neural_architecture_search](https://en.wikipedia.org/wiki/Neural_architecture_search)) to further improve our work.

**Requirement to be on campus:** No

**EIE22/10 Miniaturised LIDAR sensor**  
**Supervisor:** Prof Xiaoke Yi

**Eligibility:** Year 3/4 or Master students in Engineering and Science

**Project Description:**
The project will focus on research and innovative thinking to explore the potential opportunities for commercial exploitation of a small low power solid state scanning LIDAR (Light Detection and Ranging) sensor. Professor Xiaoke Yi currently leads a research effort together with
Professor Robert Minasian, supported by Thales & the Australian Research Council, on a photonic base silicon chip that implements a solid-state beam steering capability. The intern will work with the team to further study the capability, identify applications, and develop specific target performance measures such as: Operating range, Optical power levels, Beam scan rate, Electrical power consumption, etc.

**Requirement to be on campus:** Yes *dependent on government’s health advice

**E1E22/11 Distributed, adaptable edge-based machine learning**

**Supervisor:** Dr David Boland

**Eligibility:**
- Bachelor’s degree in electrical engineering
- Outstanding transcript (WAM>75)

**Either:**
- Knowledge training machine learning algorithms or
- Confidence with hardware design (VHDL/Verilog/High-level synthesis) or embedded systems.
- Research experience with publication record in electrical engineering (preferred)

**Project Description:**
Machine learning techniques are being used across many application domains, e.g. driverless cars, surveillance and cancer detection. Moreover, developments in algorithms and hardware accelerators are enabling their use on edge-based devices such as drones.

One point of interest is that edge-based devices are likely to be deployed in different environments to which they were trained. This means ideally each device should be locally re-trained. Our research group has been developing hardware architectures that add some limited learning capabilities to these devices. This project will aim to take advantage of this research and study:

a) How much better accuracy can be achieved with local re-training or a pre-trained sensor.

b) Can cheap distributed, locally trained sensors collaborate to outperform a single expensive sensor.

Ideally this project will be tackled by a team of students combining machine learning and hardware design experience. You will test your developments on a range of benchmark applications to demonstrate its advantages over existing solutions.

**Requirement to be on campus:** Either on campus or remotely

**E1E22/12 On-chip photonic signal processing and sensing**

**Supervisors:** Prof Xiaoke Yi and Dr Liwei Li

**Eligibility:** Year 3/4 or Master students in Engineering and Science

**Project Description:**
The rolling out of the internet of things which seeks to connect and integrate billions of devices together, and the increasing need for intelligent systems continually demand more bandwidth, higher speed signal processing. Direct signal processing in optical domain has the potential to realize orders of magnitude increase in instantaneous bandwidth, and a very high sampling frequency ability (over THz in comparison to around GHz with electronic technology), which lead to diverse applications for tackling problems of processing wideband signals, and for providing essential interference immunity. This project focuses on light weight, small size and
low power consumption integrated photonic circuits for processing wideband and high-speed signals, which applications in data centres, neuro photonics, quantum information processing and space.

Requirement to be on campus: Yes *dependent on government's health advice

MECHANICAL ENGINEERING PROJECTS

MECH22/1 High speed remote sensing system for turbulence measurements on the Great Barrier Reef
Supervisor: Dr Nicholas Williamson

Eligibility: General programming skills. A strong interest in fluid mechanics

Project Description:
This project aims to develop and test a high-speed sensor and data acquisition platform for remote measurement of turbulent flow and oxygen transport in the Great Barrier reef. The motivation is to understand the physical environment and better understand the impacts of climate change. Existing instrumentation systems are less accurate and at lower speed than what is required to make these world first measurements. The system would be built and tested in the AMME Environmental Fluid Mechanics laboratory. The work would involve integration of high-speed thermistors through a raspberry pi together with a high speed camera and/or a high speed acoustic doppler current profiler. The project will involve coding and integration of electronic components. The work would be supported by a knowledgeable instrumentation officer and our research group.

Requirement to be on campus: Yes *dependent on government’s health advice

MECH22/2 Development of technology for marine cloud brightening
Supervisor: Dr Agisilaos Kourmatzis

Eligibility: Strong interest in fluid mechanics.

Project Description:
Marine Cloud Brightening has been proposed as a method to prevent coral bleaching (https://www.savingthegreatbarriereef.org/cooling-the-reef). To achieve this, it is necessary to generate very small droplets at very high flowrates. Our research group is currently working on new nozzle technologies that have the potential to achieve this. You will work with us in helping us understand the operation of nozzle technologies that can produce high droplet number concentration aerosols with cloud seeding potential. This is a very ambitious multi-phase fluid mechanics project.

Requirement to be on campus: Yes *dependent on government’s health advice

MECH22/3 The fluid mechanics of intranasal drug delivery— a pathway for the treatment of neurological disease
Supervisor: Dr Agisilaos Kourmatzis

Eligibility: Strong interest in fluid mechanics

Project Description:
This project aims to develop an in-vitro test platform for the real-time measurement of drug transport through replicas of the human nasal cavity. Intranasal drug delivery has shown potential for the treatment of neurological diseases such as Alzheimer’s, however we have a
very poor understanding of how particles are transported in the nasal cavity. Understanding the complex interactions between nasal cavity geometry and drug particles is essential towards designing more effective drug delivery devices. In this project, you will make use of MRI images to construct an accurate replica of the human nasal cavity and then make use of visualization tools and/or computational fluid dynamics suggest design improvements to nasal drug delivery systems.

**Requirement to be on campus:** No

**MECH22/4 Three-phase turbulent fluid mechanics**
**Supervisor:** Dr Agisilaos Kourmatzis

**Eligibility:** Strong interest in fluid mechanics

**Project Description:**
One of the most complex fields in turbulent flows is that of 3-phase, or gas-liquid-solid flows. Despite how critical understanding these flows is to our everyday lives, from food production, to pollutant control and pharmaceuticals, the physics of these flows remains poorly understood. This results in high inefficiency and waste in a range of industrial systems because our ability to physically model the underlying mechanisms is too rudimentary. In this project, you will work on developing a new 3-phase flow experiment which will make the first steps towards helping us understanding this critically important field.

**Requirement to be on campus:** Yes *dependent on government’s health advice

**MECH22/5 Fibre-Optical Pressure Sensor Design by Finite Element Analysis**
**Supervisors:** A/Prof Niels Quack and Sher Ali Nawaz

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
MEMS pressure sensors are miniaturized pressure sensors, that are widely used for barometric pressure monitoring, tire-pressure monitoring systems, or altimeters. For distributed sensing applications, such as pressure monitoring on aircraft wings, the readout of the pressure can be performed optically with the integration of a pressure sensitive membrane on optical fibres. The sensitivity of the pressure sensor can be adjusted by the mechanical design of the pressure membrane. This project aims at evaluating designs of a polymer-based optical MEMS sensor, using finite element analysis software.

**Requirement to be on campus:** No

**MECH22/6 Finite Element Analysis of a Piezo-Electric Photonic MEMS**
**Supervisors:** A/Prof Niels Quack and Sher Ali Nawaz

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
Our research group has explored a variety of electrostatic Micro-Electromechanical Systems (MEMS) based actuators for implementation in Photonic Integrated Circuits (PICs). An alternative actuation method consists in the integration of piezo-electric MEMS actuators. In this project, the student will establish a finite element model for piezo-actuators and evaluate different designs for novel piezo-electrically actuated photonic MEMS devices such as switches for telecommunications or phase shifters for miniaturized LIDAR based 3D imagers.
**MECH22/7 Opto-Electro-Mechanical Characterization of Photonic Microsystems**

**Supervisors:** A/Prof Niels Quack and Sher Ali Nawaz

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
In this project, the student will dive into the exciting world of Micro-Electro-Mechanical Systems (MEMS), with the hands-on characterization of MEMS components in cutting edge Photonic Integrated Circuits (PIC), the optical equivalent of electrical integrated circuits. After an introduction to the key features of the experimental setup, the student will measure and extract key performance metrics of the Photonic MEMS Devices, such as spectral response, optical losses and the electro-mechanical response for a variety of components of a prototype photonic MEMS chip, such as Photonic MEMS Switches and Photonic MEMS Tuneable Filters for Fiber-Optical Telecommunication Systems.

**Requirement to be on campus:** Yes *dependent on government’s health advice

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**MECH22/8 Buoyant fires and their suppression by enhanced chemicals**

**Supervisors:** Prof Assaad Masri, Agisilaos Kourmatzis and Vinny Gupta

**Eligibility:** This is open to final-year students only with HWAM>75.

**Project Description:**
The project aims at investigating the structure and stability of buoyant flames which simulate compartment fires. The suppression of such fires by water mist enhanced with chemicals is also studied. The challenge here is the dynamics of the spray droplets and access to the reaction zone for maximum effectiveness.

**Requirement to be on campus:** Yes *based on government’s health advice

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**MECH22/9 Combustion of Green Fuels (Hydrogen and its derivatives)**

**Supervisors:** Prof Assaad Masri, Dr Matthew Dunn and Andrew Mcfarlane

**Eligibility:** This is open to final-year students only with HWAM>75.

**Project Description:**
Combustion will remain central to the process of decarbonization particularly in power generation, heavy duty transport and high-temperature process industries. The project will investigate fundamental issues associated with the turbulent combustion of green fuels (also referred to as power-fuels, or electro-fuels such as hydrogen and its derivatives).

**Requirement to be on campus:** Yes *based on government’s health advice

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**MECH22/10 Microstructural evolution along the build direction of a 17-4PH stainless steel fabricated by laser powder-bed fusion**

**Supervisors:** Prof Xiaozhou Liao and Mr. Hao Wang

**Eligibility:** WAM>75 and Undergraduate candidates must have already completed at least 96 credit points towards their undergraduate degree at the time of application.

**Project Description:**
Additive manufacturing (AM) offers distinct advantages over conventional manufacturing, including design freedom, near net or net shape production, efficient use of materials, and short lead times. AM of metallic materials using techniques like laser powder-bed fusion consists of cyclic rapid thermal loadings and different layers in the as-built component experience different thermal histories. These result in complex stress and thermal gyrations and therefore lead to microstructural heterogeneity along the build direction that significantly affects local and global mechanical properties of the component produced by AM. Investigation of the microstructural evolution of AM components is therefore critical for us to understand how printing parameters affect mechanical properties of AM components. In this project, we will choose 17-4PH stainless steel as the model material due to its sensitivity to thermal history and deformation. Laser powder-bed fusion will be used for AM and scanning electron microscopy will be used for microstructural characterisation.

**Requirement to be on campus:** Yes *based on government’s health advice

**MECH22/11 Mechanical behaviour of third-generation advanced steels**

**Supervisor:** Dr Xianghai An

**Eligibility:** High achievement in a relevant undergraduate engineering degree (a WAM of 75 or above). This winter project has the option to be combined with an honours project.

**Project Description:**
Steel is the workhorse of our infrastructure. Stronger, tougher steels are always needed to reduce weight and improve safety in transportation, enhance architectural flexibility in construction, and improve performance in heavy machinery. Recently, the third-generation advanced high strength steels (AHSS) have been developed. These steels have lower alloying cost and less difficulty on manufacturing than those of first- and second-generation AHSS but exhibiting better tensile properties.

With respect to the perspective engineering applications of these strong materials, their mechanical behaviour and cryogenic properties are also essentially crucial concerns owning to safety issues, which will be explored in this project by applying high resolution mapping of strain distribution, cryogenic tensile experiments, and advanced characterisation techniques. Timely exploiting the knowledge of the mechanical behaviour and cryogenic properties of the AHSS is important both scientifically, for the in-depth comprehension of their deformation behaviour, and technologically, for assessing their service utilities in safety-critical structural components.

**Requirement to be on campus:** Yes *based on government’s health advice

**MECHATRONICS ENGINEERING PROJECTS**

**MECHATRON2022/1 Open-source robotic vision with 4D light field cameras**

**Supervisor:** Dr. Donald Dansereau

**Eligibility:**
- Strong programming skills
- Basic knowledge of image processing, camera calibration, and/or computer vision would be an asset.

**Project Description:**
Working with researchers at the Australian Centre for Field Robotics, this project will develop robotic vision toolchains for working with a new class of light field camera that directly captures 4D radiance fields.

Light field imaging is akin to measuring holograms, giving us rich information about visually complex scenes characteristic of dense vegetation, crops, and reefs, as well as urban...
environments arising in autonomous driving and drone flight. This work has the potential to advance the state of how robots use this technology to perceive and represent their world.

In this work you will advance the imaging software pipeline used to make sense of the data collected using prototype 4D light field cameras. There is a potential to contribute directly to the Light Field Toolbox for Matlab, the de facto tool used across communities and named in the JPEG standard for working with this exciting new technology.

**Requirement to be on campus:** No

**MECHATRON2022/2 Hyperspectral Imaging on Autonomous Underwater Vehicles**

**Supervisor:** Prof Stefan Williams

**Eligibility:**
- Strong programming skills
- Basic knowledge of image processing, camera calibration, and/or computer vision would be an asset.

**Project Description:**
Hyperspectral imaging (HSI) observes spectra in narrow spectral bands spread across the electromagnetic spectrum. For marine applications, hyperspectral imaging from satellite or airborne sources is used for shallow-water habitat mapping and tracking algal blooms. However, due to the high attenuation of light in water, using airborne devices is limited to observing shallow waters. There is significant interest in underwater hyperspectral cameras mounted on autonomous underwater vehicles (AUVs), enabling greater resolution and the imaging of deeper areas. This will foster science applications including habitat mapping, geology and archaeology.

The objective of hyperspectral imaging is to estimate the surface reflectance. To provide an accurate estimation, the light sources illuminating the seafloor need to be accounted for. This project will investigate methods to calibrate a hyperspectral camera mounted on an AUV. It will involve making calibration rigs and the integration of hyperspectral sensors.

**Requirement to be on campus:** No

**SPACE ENGINEERING PROJECTS**

**SPACE22/1 Demonstration of an On-orbit Servicing Mission Using a Satellite Simulator**

**Supervisor:** Dr Xiaofeng Wu

**Eligibility:** Space Engineering student only.

**Project Description:**
The purpose of this research is the advancement of trusted and autonomous satellite operations through embodied intelligence, in the form of AI enhanced reactionless control. Applying such control algorithms to OOS (On-orbit servicing) platforms would enhance their interactions with satellites that require servicing. Such a platform would be capable of making Earth observation satellites very dynamic and flexible through on orbit repairs.

The student will test the service module on a 6 degrees-of-freedom air-bearing table, which simulates the zero-gravity environment. The emphasis will be on the stability of the satellite platform while the service module is in motion. The student will also explore the navigation and control algorithms for proximity operations in orbit.

**Requirement to be on campus:** Yes *dependent on government’s health advice.*