Updated 08/03/2024

2024 UQ Winter Research Project Description

Project Title:	Damage Mechanics models for Solid State Batteries
Project Duration:	36 hours per week for 4 weeks, offered on-site
Positions Available:	1
Description:	Solid State Batteries, particularly those based on Sodium and Lithium -Ions are widely recognised as one of the most promising candidates for the next-generation of batteries. However, their commercialisation has been impeded by the chemo-mechanical degradation of the solid electrolyte and electrode/electrolyte interface. The ultimate objective of the project is to develop advanced numerical models that enhance our understanding of damage mechanisms in solid-state batteries and provide a computational tool for exploring effective damage mitigation strategies in future battery materials and designs. The project scope will involve familiarisation with the governing equations for steady-state galvanostatic operation of solid-state batteries and the numerical simulation using a generic FEM solver (MATLAB, COMSOL, etc).
Expected Outcomes and Deliverables:	The scholar may gain skills in advanced mathematical modelling and have the opportunity to generate a publication from their research. They will be required to produce a report at the end of their project and submit codes/models generated during their project.
Suitable for:	The project is suitable for: • 3rd – 4th year Mechanical Engineering students (pre-requisites MECH2700, MATH2010, MECH3780), • 3rd year Bachelor of Mathematics students (Applied Mathematics Major)
Supervisor:	Dr Aditya Khanna
Further info:	Please contact Dr Aditya Khanna on aditya.khanna@uq.edu.au.

Project Title:	Investigation into the feasibility of a detonation driver for the X3/X3R expansion tube / reflected shock tunnel
Project Duration:	36 hours per week for 4 weeks, offered on-site
Positions Available:	1
Description:	Hypersonic flight is defined as flight at Mach 5 or above – 5 times higher than the speed of sound. Hypersonic flight has many applications such as access-to-space, planetary entry, and high-speed flight through the Earth's atmosphere. Hypersonic impulse test facilities are an important and economical way to study hypersonic flight and refine the designs of hypersonic vehicles. Most high-enthalpy hypersonic test facilities are based on the shock tube concept, where a diaphragm is broken between a high pressure 'driver' gas and a low pressure 'test' gas, driving a shock wave into the low pressure test gas. This shock wave is used to generate a hypersonic test flow, generally by stagnating the shocked test gas against the end of its tube and bleeding the gas out slowly to feed a hypersonic nozzle – in what is called a reflected shock tunnel. A high performance shock tube relies on a high sound speed driver gas to driver a strong shock to the test gas. While some facilities are just driven by a light gas, such as hydrogen or helium, at room temperature, generally some means of the raising the temperature too is required. This is either done by directly heating the test gas with a heater, with a piston, to compress the gas isentropically, combustion or detonation to raise the temperature through heat release of a combustible mixture, or an electric arc to dump electricity into the test gas to heat it. In Australia, the free-piston driver is common as it gives high performance for a relatively simple design and due to its legacy in Australia. The free-piston driver is an Australian invention and there have been many free-piston driven facilities in Australia over the last 60 years. UQ's X3/X3R facility is the largest shock tunnel in Australia and it operates as a multi-mode reflected shock tunnel and expansion tube. It is free-piston driven. While the free-piston driver has higher performance than a detonation driver, one advantage of a detonation driver, is the potential for longer test times at low-enthalpy operation. Detonation drivers are relatively common overseas, but are relatively unknown in Australia. As X3R is generally used for testing scramjet vehicles around Mach 7, a detonation driver may potentially be advantageous for these conditions, but whether it would be or not is still unknown. For this reason, this project wants to investigate the feasibility of a detonation driver for X3/X3R to see if it would in fact offer any benefits to the facility for operation at Mach 7 if it was implemented. If the detonation driver does offer benefits, the plan is to do a rough design of a small-scale pilot detonation driver which could be used to further investigate the potential benefits of a detonation driver for the facility, at a scale which is relatively safe and inexpensive to start with.
Expected Outcomes and Deliverables:	Scholars will gain knowledge in simulating and modelling hypersonic impulse facilities and how to roughly budget for a small engineering design project. The expected outcome of this project is a short report detailing the potential benefits of a detonation driver for the X3 facility and the cost required to build a pilot small-scale detonation driver which could be used to further investigate the potential of building a detonation driver for the facility.

Suitable for:	This project is open to 3rd and 4th year Mechanical and Aerospace students with knowledge of fluid mechanics, hypersonics, combustion, and engineering analysis such as having done MECH2410, MECH2700, MECH3410, AERO4470 and AERO4450. As this is such a short project, it will be hard to take students without those skills.
Supervisor:	Dr Chris James (c.james4@uq.edu.au)
Further info:	Before you submit an application, please contact the Project Superviser (Dr Chris James) to discuss further.

Project Title:	Commissioning of tabletop pulse supersonic test facility
Project Duration:	4 weeks, 20 – 36 hrs per week, on-site
Positions Available:	1
Description:	In a conventional supersonic test facility, high pressure stagnated air, stored in a large reservoir, is expanded through a diverging nozzle to produce a supersonic flow at the nozzle exit. This operating concept relies on the back pressure on the nozzle being close to a vacuum, therefore the nozzle and test article are contained in an evacuated test chamber. The test duration depends on how long the supply of high-pressure air lasts, and also how soon the pressure in the test chamber rises above a level at which the nozzle ceases to function correctly. Therefore, this type of facility intrinsically has a limited test duration and is typically referred to as a supersonic "blow-down" facility. One concept to extend the test duration is to operate the facility in a pulsed mode. Each time the facility pulses, valves in the nozzle throat temporarily open to allow flow of reservoir gas through the nozzle. After a short start-up time, flow through the nozzle becomes steady, and experiments can be temporarily performed. During this time, and also when the pulsing stops, vacuum pumps continuously pump down the vacuum chamber. If the duration between pulses is timed appropriately, the vacuum pump can maintain sufficiently low pressure in the test chamber to allow testing on an ongoing basis. This is the concept between the pulsed supersonic test facility. It has great potential as a teaching tool, since it would allow real time changes to a test model, such as varying its angle of attack, while the result is viewed in real time (for example, to show changes to oblique shock angles leading to eventual shock detachment). Such a system would appear continuous and seamless to the observer if imaging and diagnostics were synchronised appropriately to the fluid pulsing. UQ recently has recently designed and fabricated a table-top pulsed supersonic test facility. After an initial round of commissioning, several aspects of the test facility have been identified as requiring modification. Characterisation of the test flow also remains to be done in terms of flow duration and flow properties. The goal of this project is to survey the original commissioning results, identify/design and incorporate any required modifications, and to commission the upgraded facility.
Expected Outcomes and Deliverables:	The student is expected to prepare a commissioning report for the facility at the completion of the project. The student will develop their skills in fluid mechanics, electronics, sensors, data acquisition systems, laboratory skills.
Suitable for:	This project is open to applications from mechanical engineering students who have successfully complete their 3rd year courses. The project requires a student with strong fluid mechanics knowledge; experience with electronics, sensors, and data acquisition systems; strong laboratory skills; and a commitment to get the test facility operational during the course of their project.
Supervisor:	Dr David Gildfind
Further info:	Please contact Dr David Gildfind on d.gildfind@uq.edu.au.

Project Title:	Piston Braking system for X3 shock tube
Project Duration:	4 weeks, 20 – 36 hrs per week, on-site
Positions Available:	1
Description:	The operational envelope for free piston driven shock tubes has some limits placed due to the dynamics of the piston, and the possibility of the piston making a return stroke if the driver gas in front of the piston doesn't vent at the appropriate rate. Inertial braking devices have been used effectively on such facilities before, and are currently used on the T4 facility in Mech Eng. A complication arises on the larger X3 facility as the piston is not removed between shots, and when it is returned to the launcher it is likely to jam. A concept is to be investigated which involves a mechanism for releasing the brakes internally as the piston is returned to its launch position.
Expected Outcomes and Deliverables:	Students will gain skills in the application of statics and dynamics in a complex mechanical situation where both are important. Interaction of the dynamic effects with a load bearing structure has generic engineering applicability and will be a useful educational experience.
Suitable for:	Students should have good analytical abilities, and sound knowledge of structures and materials.
Supervisor:	Professor Richard Morgan
Further info:	Please contact Professor Richard Morgan on r.morgan@uq.edu.au

Project Title:	Sodium ion batteries for grid connect storage
Project Duration:	4 weeks, 20 – 36 hrs per week. As this work will be based in the laboratory, this will be predominately on-site project. Data analysis can e completed remotely.
Positions Available:	1
Description:	Sodium-ion batteries (NIBs) hold a great promise for scalable energy storage applications due to the natural abundance of sodium resources. However, one of the grand challenges for the NIB technology is the low energy density. Cathode materials are key to the energy density of batteries. Sodium transition metal layered oxides are the most promising among various NIB cathode candidates. In this project, the student will develop a low-cost cathode material for NIBs and complete associated battery testing to understand the structure-performance relationship. This project will involve the synthesis and characterisation of the cathode materials, so the student should either have laboratory experience or be interested in work in a laboratory.
Expected Outcomes and Deliverables:	The student will develop a fundamental insight into how batteries work, which would help understanding other electrochemical energy systems and larger-scale batteries. In addition, the student will develop synthesis skills and data analysis skills to correlated battery performance with material characteristics.
Suitable for:	This project is open to applications from 3rd or 4th year students with a background or interest in materials science and engineering.
Supervisor:	Associate Professor Ruth Knibbe
Further info:	Please contact Associate Professor Ruth Knibbe on ruth.knibbe@uq.edu.au

Project Title:	Computing sub-grid particle trajectories coupled with the Lattice Boltzmann Model
Project Duration:	This project looks for 28-36 hrs (4-5 days) per week commitment over the 4-week winter project period. Work is preferred on-site but hybrid arrangements are available.
Positions Available:	1
Description:	**What this project will do:** This project will build on a Discrete-Element Model coupling that currently allows particles to be resolved in a fluid modelled by the Lattice Boltzmann Model in the research code, TCLB (https://tclb.io/about/), to simulate the trajectories of sub-grid particles. Scenarios often arise in air-filtration, particulate modelling, and respiratory analysis where the particles of interest are on the order of microns while the flow domain is on a centi-to-meter scale. This restricts computational studies from fully resolving the forces acting on the surface of particles and requires correlations to couple the fluid and solid domain (e.g., through drag or lift relations). **Background:** Recently, interest has arisen to efficiently model the deposition of pharmaceuticals within the upper respiratory system. The droplets encapsulating the desired pharmaceuticals are orders of magnitude smaller than the flow domain required for the upper respiratory system and as such must be simulated as a sub-grid entity. This winter project will develop the software capability to model these particles and verify the performance/accuracy of their trajectories in simple flow cases. **Requirements:** Students applying for this project should have a strong background and interest in software development and computational mechanics. The TCLB code is written in C++/Cuda so although not compulsory, exposure to these languages would be very beneficial.
Expected Outcomes and Deliverables:	The successful applicant will gain skills in research software development and exposure to best practice code dev, maintenance, and production. The applicant will be expected to provide an oral presentation of their results along with a slide-deck outlining the benchmark cases used for verification.
Suitable for:	This project is open to applications from students with a background in computational methods and an interest in programming.
Supervisor:	Dr Travis Mitchell
Further info:	Please contact Travis if you are interested to apply (t.mitchell@uq.edu.au). This project will be co-supervised by Mr Nicholas Paraskevas and supported by Mr Dmytro Sashko.

Project Title:	Assessing the flow rate of bottles and teats for infants
Project Duration:	4 weeks, 36 hours per week
Positions Available:	1
Description:	Teat flow is an important consideration in managing feeding progression in young infants, particularly those with feeding difficulties. Unfortunately, previous testing has found that many teats marketed as slow or extra-slow flowing actually have variable flow rates, from 3mL/min to 75mL/min. Additionally, some teats also have high variability within the same brand, presenting a different flow each time a new teat of the same flowrate/ brand are presented to the child. This project proposes to validate local teat flow testing equipment, and to test with a range of common medium and faster flowing teats, so that there is a full spectrum of information available for clinicians. This work is highly important and immediately translatable at the bedside for the clinical care of infants with feeding difficulties.
Expected Outcomes and Deliverables:	The researcher will complete experimental work – including development of testing equipment, data collection, and data analysis. Some design work is possible, leading to 3D printing of some updated experimental equipment. The outcomes of the work should be written up in a report at the end of the program.
Suitable for:	This project is open to applications from students with a background in engineering or science and an interest in experimental design. Some CAD and 3D printing experience is advantageous, but not essential.
Supervisor:	Dr Carolyn Jacobs
Further info:	Please contact Dr Carolyn Jacobs on c.jacobs@uq.edu.au

Project Title:	Investigation of Squeal/Flutter Phenomena
Project Duration:	4 weeks, 36 hours per week
Positions Available:	1
Description:	Squeal is a tonal noise (in the hearing range of 1-10kHz) from a frictionally excited unstable mode of vibration that results from the slowing of a vehicle with disk brakes (brake squeal) or cornering of a train (wheel squeal). Its occurrence is often identified as 'fugitive', and unpredictable, ie a 'squealing' brake does not squeal during all braking events. Mode coupling also occurs in aeroelastic structures and causes flutter. There have been many theories formulated to understand the phenomenon of squeal including the main mechanisms of; falling friction, sprag-slip and modal coupling (or 'Binary flutter') but the merits and applicability are keenly debated. Similar research is being undergone with flutter in wind turbines. To address this, the UQ nonlinear mechanics team recently published the closed form identification, quantification and mitigation of squeal and flutter occurrence and amplitude under all mechanisms, for the first time. This unique insight has inspired the development of two unique experimental testrigs to validate the modelling predictions. This project aims to obtain and analyse the testrig experimental and/or CFD data to achieve this.
Expected Outcomes and Deliverables:	A validation between mathematical predictions and experimental measurements of squeal and/or flutter.
Suitable for:	4th or 5th year Mechanical or Mech/Aero/Mechatronics Engineering student. Strong ability and interest in dynamics.
Supervisor:	Prof Paul Meehan
Further info:	Please contact Prof Paul Meehan on meehan@uq.edu.au