School of Mechanical and Mining Engineering
Summer Research Projects

Project title:	**Super-sonic/Hypersonic air speed sensor for ground and flight testing**
Project duration:	10 Weeks
Description:	BLUESKY is a collaborative project between UQ and the German Aerospace Centre (DLR). One of the aims of the project is to improve sensors used during ground and flight test experiments. Critical questions that typically remain unanswered are: (a) how accurate is the sensor? (b) would I measure the same if the experiment is performed in a tunnel or during flight? (c) how can I improve the system? To contribute to these overall aims, you will work review, analyse, and compare different sensor options and work with PhDs and postdocs in the CfH to identify future experimentation options.
Expected outcomes and deliverables:	You will learn about how to take aerodynamic measurements and the technical nuances associated with adding a sensor into a more complex system. You will also gain connections to the international aerospace community (e.g. DLR)
Suitable for:	Suitable for student with interest in aerospace, space, high speed flows, and rockets/scramjet vehicles. Experience with CFD simulations or aerodynamic experiments is highly desirable.
Primary Supervisor:	Dr Ingo Jahn
Further info:	i.jahn@uq.edu.au

Project title:	**Dr Mingyuan LU: developing FIB-assisted micro-mechanical testing technique for assessing the interfacial adhesion of SiN passivation layer on GaAs semiconductor wafer**
Project duration:	10 weeks
Description:	In this project, a micro-mechanical testing methodology for measuring interfacial adhesion of SiN films on GaAs substrates will be developed. Focus ion beam (FIB) milling will be used to manufacture micro-scale testing structures and nanoindenation will be utilized to apply load to the miniaturized specimens. This technique will be able to generate interfacial delamination events, which then enable quantitative analysis of the interfacial toughness.
Expected outcomes and deliverables:	A reliable testing method for evaluating the adhesion of SiN passivation layer on GaAs wafer will be developed.
Suitable for:	The student should have material science background, experience of materials characterization and is able to do simple material mechanic analysis.
Primary Supervisor:	Dr Mingyuan Lu
Further info:	Please contact Dr Lu (m.lu1@uq.edu.au) if you would like more information on this project.

Project title:	**Professor Matt Dargusch: Additive manufacturing as an alternative to Blacksmith metal working**
Project duration:	10 weeks
Description:	The research project involves assessing and evaluating the potential for additive manufacturing as an alternative to traditional blacksmith metal working practices.
Expected outcomes and deliverables:	Applicants will develop design skills for net shape manufacturing
Suitable for:	The successful applicant must have previous traditional blacksmith metal working experience.
Primary Supervisor:	Professor Matt Dargusch
Further info:	For further information please contact Prof. Dargusch - m.dargusch@uq.edu.au

Project title:	**Dr Zhongwei Chen: Coal mechanical and petro-physical properties testing**
Project duration:	10 Weeks
Description:	This project is mainly laboratory testing work, involving the preparation and characterisation of coal samples from different basins, the execution of various types of lab measurements, and the analysis and reporting of the results.
Expected outcomes and deliverables:	Upon the completion of this project, the applicant is expected to gain reasonable understanding of different material lab testing techniques, and learnt skills how to plan and execute a project independently.
Suitable for:	Students who are in third year (or above) and interested lab testing work.
Primary Supervisor:	Dr Zhongwei Chen
Further info:	zhongwei.chen@uq.edu.au

Project title:	**Structural simulations of a supersonic propeller using FEA**
Project duration:	10 Weeks
Description:	The research project involves investigating the structural loads on a supersonic propeller in flight to inform the blade design and choice of materials. This includes choosing appropriate modelling for an accurate representation of the blade, running the simulations and evaluating the results. If time allows the project can be extended to investigate fluid structure interaction.
Expected outcomes and deliverables:	Experience in the structural design of a complex part in a supersonic flow environment. Expectations: FEA modelling of a propeller blade. Writing a short report about what has been done, what the results were and how this affects the design.
Suitable for:	A fourth year student in Aerospace Engineering with an interest in supersonic/hypersonic applications with experience in FEA analysis.
Primary Supervisor:	Dr Jens Kunze
Further info:	Please contact me on j.kunze@uq.edu.au if you are interested in more information about the project.

Project title:	**Dr Chris James: Re-commissioning and upgrade of ablating test models**
Project duration:	10 Weeks
Description:	During planetary entry, the surface of space vehicles generally reach several thousand kelvin and the specifically designed carbon heat shield begins to burn away through the process of ablation. While experimental test times in the impulse wind tunnels at UQ are of the order of a thousandth of a second, meaning that test models do not heat up appreciably during the test time, real planetary entry surface temperatures can be simulated in UQ's impulse wind tunnel facilities by electrically pre-heating the test model before the experiment. This involves using a large welding power supply to quickly heat a carbon test model until it is glowing red hot, and then the tunnel can be fired at it. As the test models are made of carbon, they also allow ablation processes to be studied. This is a novel technique developed at UQ which allows hot wall phenomena to be studied in impulse wind tunnels for the first time. While early work at UQ focused on heating simple geometries to temperatures up to 3,800 K, later work focused on integrating heated sections into more complex geometries at slightly lower maximum temperatures. As an upcoming project aims to further study ablating phenomena in very high enthalpy flows, such as return from Mars, where very high surface temperatures are seen, this work aims to re-commission some of the test models from earlier work so that they can be used again, as well as performing upgrades to these early test models and others for the demanding needs of future experiments.
Expected outcomes and deliverables:	Expected physical outcome is re-commissioning and testing of an ablating test model from a previous PhD at UQ, as well as upgrades to it and other existing ablating test models at UQ. This re-commissioning will involve engineering design and transient thermal analysis using ANSYS, before testing of the model in a vacuum chamber to prepare it for experiments, with optical techniques used to measure surface temperature during the heat cycle. Hopefully, preliminary experiments will also be able to be performed with the model during the project.
Suitable for:	3rd, 4th or 5th year Mechanical or Mechatronic Engineering students. Some engineering design knowledge and an interest in hypersonics, heat transfer, and fluid mechanics would be useful, but not essential.
Primary Supervisor:	Dr Chris James
Further Information	c.james4@uq.edu.au

Project title:	**Prof Richard Morgan: Shock wave attenuator for high speed piston**
Project duration:	10 Weeks
Description:	This project aims to investigate and design a damper plate to be mounted on the front of a piston used in the X3R reflected shock tube. The shock tunnels at UQ use the 'free piston driver' concept to generate the high temperature and pressure gas needed to drive shock tube flows. Under some conditions, unwanted shock waves form in front of the piston causing transient nonuniformities in the flow which reduces its merit as a test facility. One possible way to reduce the magnitudes of these waves is to mount a 'baffle plate' on the front of the piston, which vents some of the shock heated gas into a cavity behind the baffle, thereby reducing the strength of the reflected waves.
Expected outcomes and deliverables:	You will gain understanding of transient flow phenomena, and analytical and numerical skills. You will gain design skills, related to the operation of objects subjected to extreme inertial loading
Suitable for:	Students with good numerical and analytical skills and a practical approach to design.
Primary Supervisor:	Professor Richard Morgan
Further info:	r.morgan@uq.edu.au

Project title:	**Development of a High-Efficiency Fracture Test for Technical Ceramics (BMECT-C)**
Project duration:	10 weeks
Description:	The BMECT represents a major advance in the ability to rapidly assess the relative fracture resistance of a set of candidate wear-resistant materials for a given application. It has been used for several campaigns of fracture resistance evaluation for white cast irons and high-C steels, showing excellent statistical data quality. The aim of the project is to develop the BMECT-C into a viable test method for evaluation of fracture resistance of ceramic materials.
Expected outcomes and deliverables:	You will be exposed to senior product development staff from the industry partner company (a Scandinavian-based manufacturer of equipment & consumables for mining industry operations). You will be trained in the safe & proficient use of machine workshop equipment with diamond tooling for machining of ceramic materials. You will be trained in the techniques & practices of high-integrity laboratory research. The materials testing method you will be developing is expected to gain widespread use in industry. If your work is successful, you can be a co-author of a research journal publication.
Suitable for:	3rd-year student of Mechanical Engineering or related discipline. Materials knowledge desirable. Demonstrable work-ethic and attention to detail. Demonstrable skills in preparation of written reports.
Primary Supervisor:	Dr Jeff Gates
Further info:	Dr Yahia Ali (post-doc) y.ali@uq.edu.au

Project title:	Effect of Nb-CVF on Abrasion and Fracture Resistance of NbC containing White Cast Irons
Project duration:	10 weeks
Description:	High-Cr white cast irons are particulate-reinforced composite materials in which a network of very hard (~1400 HV) chromium-rich carbides (M7C3) are supported by a moderately hard (~600 HV) matrix of martensitic steel. New research is exploring the potential for additional performance benefits by adding NbC, which is even harder (~1800 HV). A series of castings has been prepared with a wide range of volume fractions of NbC. Properties and performance will be evaluated using UQMP's innovative suite of industrially-realistic laboratory evaluation devices.
Expected outcomes and deliverables:	You will receive training in a variety of techniques for high-integrity laboratory research. You will generate data contributing to a large industrially-funded research project. • Careful cataloguing and durable labelling of all specimens. • Accurate heat treatment to specified protocols; surface grinding to specified dimensional tolerances. • Measurement of Vickers hardness; Plot graph of hardness versus Nb-CVF (with appropriate treatment of statistical scatter). • ASTM G65 rubber wheel abrasion tests; Plot graph of abrasion versus Nb-CVF. This will provide perspective when industry partners enquire about results from "standard" test. • Making ready for conduct of ball mill abrasion test, ball mill edge-chipping test and inner circumference abrasion test, which will be performed by MECH4500 thesis students in 2021 semester 1.
Suitable for:	3rd-year student of Mechanical Engineering or related discipline. Materials knowledge desirable. Demonstrable work-ethic and attention to detail. Demonstrable skills in preparation of written reports.
Primary Supervisor:	Dr Jeff Gates
Further info:	Dr Yahia Ali (post-doc) y.ali@uq.edu.au

Project title:	**Dr Mingyuan LU: In vitro biodegradation behaviour of akermanite/PHBV bone scaffold for tissue engineering application**
Project duration:	10 Weeks
Description:	In the proposed project, akermanite/PHBV biocomposites will be developed for making bone scaffolds for tissue engineering application using SLS processes. The biodegradation behaviour of the composite scaffolds will be studied in vitro by incubating the scaffolds in cell-culture. The change of molecular weight, crystallinity, weight, surface chemicsty of the scaffold with time will be examined to study the degradation mechanism of the composite scaffold in vitro.
Expected outcomes and deliverables:	Understanding of the degradation mechanism of the biocomposite scaffold in vitro.
Suitable for:	The student should have material science background, experience of materials characterization and is able to do simple material mechanic analysis.
Primary Supervisor:	Dr Mingyuan Lu
Further info:	Please feel free to contact me on m.lu1@uq.edu.au, if you would like more information on this project.

Project title:	**Dr David Gildfind: Experimental techniques for spacecraft magnetohydrodynamic aerobraking**
Project duration:	10 Weeks
Description:	Magnetohydrodynamic (MHD) aerobraking proposes using a strong magnetic field to manipulate the hot, ionised gas which forms in front of a spacecraft during planetary atmospheric entry. The result is a reduction in instantaneous heating to the vehicle surface, as well as a controllable increase in drag which can be used to target more optimal reentry trajectories. Experiments at UQ's Centre for Hypersonics are currently underway to measure the effects of the magnetic field on vehicle drag, shock stand-off, heating to the surface, and the effect of the magnetic field on radiation transport through the flow field. Measurement of these key spacecraft loads is challenging due to the extraordinarily harsh flight conditions, and the presence of the electrically conducting plasma and induced currents through the shock layer. This project will examine instrumentation techniques and strategies to overcome these ongoing challenges in our hypersonic ground test experiments. Specifics of the study will be determined based on the candidate's technical experience and areas of particular strength, to ensure the best match between candidate and project, and ensure the most productive outcomes.
Expected outcomes and deliverables:	The applicant will gain hands-on experience working on experimental hypersonics, including experimental diagnostics and experimental design and execution. The expected outcome of this project will be a technical report and/or technical paper detailing the findings of the study.
Suitable for:	Strong aptitude for experimentation and data analysis; strong literature review skills and critical thinking ability; strong analytical skills and strong background in physics, fluid mechanics, and heat transfer; experience with electronics/instrumentation.
Primary Supervisor:	Dr David Gildfind
Further info:	Please contact me on d.gildfind@uq.edu.au for further details

Project title:	**Dr Amelia Zhang: Wear resistant coatings for rotary blood pumps**
Project duration:	10 weeks
Description:	The research project aims to develop more durable and haemocompatible rotary blood pumps through building wear resistant and haemocompatible coating on the surfaces of pump impeller and housing wall, which is made of Ti6Al4V. Ti anodizing is a potential technical route to be explored.
Expected outcomes and deliverables:	The applicants can gain knowledge and hands-on experiences on rotary blood pumps, anodizing and materials preparation, characterization and mechanical properties test.
Suitable for:	This project suits students with background of mechanical engineering, inorganic chemistry and biomedical engineering.
Primary Supervisor:	Dr Amelia Zhang
Further info:	Please feel free to contact amelia.zhang@uq.edu.au, if you would like more information on this project.

Project title:	**Dr Amelia Zhang: Antithrombogenic ECMO coatings for COVID-19 patients**
Project duration:	10 Weeks
Description:	The research project aims to tackle with the thrombosis issue of extracorporeal membrane oxygenation (ECMO), more preferred targeting COVID-19 patients running on ECMO. Novel antithrombogenic coatings will be developed on the surfaces of ECMO circuit, which is made of polymers like polyvinyl chloride (PVC), polypropylene (PP) and polymethylpentene (PMP).
Expected outcomes and deliverables:	The applicants can gain knowledge and hands-on experiences on ECMO, antithrombogenic coatings, coating preparation, characterization and evaluation.
Suitable for:	This project suits students with background of polymer chemistry, organic chemistry and biomedical engineering.
Primary Supervisor:	Dr Amelia Zhang
Further info:	Please feel free to contact amelia.zhang@uq.edu.au, if you would like more information on this project.

Project title:	**Manufacturing and testing of functional antenna structures**
Project duration:	10 Weeks
Description:	Functional antenna structures are structural components with an integrated antenna that remains operational while withstanding service loads. This integration can be achieved by embedding the antenna within the structure, or by adhesively bonding a shape-conforming antenna to an existing structure. This project will assess the durability of such an antenna which is designed to be adhesively bonded to vehicles used in Defence applications.
Expected outcomes and deliverables:	This project will provide the applicant with tangible, hands-on experience of contributing to a collaborative project between universities, industry and Defence. The successful applicant will gain experience manufacturing composite structures and performing mechanical testing to determine the durability and strength limits of the structures. This will require learning the mechanical and materials engineering principles behind the design of composite structures. The main deliverable of the project will be demonstrating a successful methodology for the assessment of the functional antenna structure durability and strength limits.
Suitable for:	Students will be required to work professionally and independently, including liaising with members of the UQ Composites group, faculty workshop staff and laboratory support staff. Successful applicants should have at least a basic familiarity with the following concepts: composite materials, mechanical testing, adhesive bonding. Strong written communication skills are required, as documentation and reporting is critical to the project.
Primary Supervisor:	Dr Mitch Dunn and A/Prof Martin Veidt
Further info:	Feel free to contact Dr Mitch Dunn (m.dunn1@uq.edu.au) who leads a DMTC research project on Functional Antenna Structures for more information on this project.

Project title:	**Dr Christopher Leonardi: Improving heat transfer in nuclear reactors via surface engineering for favourable hydrophobicity**
Project duration:	10 Weeks
Description:	Hydrophobic, hydrophillic and even superhydrophobic/phillic surfaces have recently received significant interest in applications such as self-cleaning, corrosion protection, drag reduction, and heat transfer enhancement. When considering heat transfer in particular, the process of boiling has been used as an effective heat transfer mechanism in both water-cooled nuclear reactors and fossil fuel powered plants. Its application tends to a limit of critical heat flux (CHF) as the process progresses from nucleate to film boiling. After surpassing the CHF, the surface is covered by a thin vapor layer causing its temperature to rapidly increase and possibly experience surface burnout. As such, it is favourable to increase the CHF limit as this can translate to higher thermal margins and allow for reactors to be operated at higher power densities, ultimately improving both the safety and cost of these systems.
Expected outcomes and deliverables:	This aim of this project is to (i) verify and validate the liquid-gas-solid contact behaviour of a recently developed computational multifluid dynamics model, and then (ii) apply this model to analyse the hydrophobicity of engineered surfaces to determine design(s) that potentially improve the CHF limit. The successful applicant will develop new skills in computational fluid dynamics, multiphase fluid mechanics, and model development, verification and validation.
Suitable for:	This project is open to students with a background in mechanical engineering, mathematics or applied physics. Interest and demonstrated competence in fluid mechanics, computational fluid mechanics and applied mathematics would be of tremendous benefit to the project.
Primary Supervisor:	Dr Christopher Leonardi
Further info:	This project will be co-supervised by Dr Travis Mitchell (t.mitchell@uq.edu.au) .

Project title:	**Dr Christopher Leonardi: Physics-based machine learning for inexpensive fracture permeability computation**
Project duration:	10 weeks
Description:	The project aims to combine partial differential equation (PDE) modelling of a physical process with techniques from machine learning to develop a cheap replacement for expensive computations. The physical problem to be tackled is the calculation of the hydraulic permeability of a rock fracture, which is a widely used parameter in many applications. It can be calculated using a range of different methods, such as solving Reynolds, Stokes or Navier-Stokes PDEs. The methods based on 3D Navier-Stokes equations are believed to be most precise but can be very expensive. In contrast, 2D Reynolds equations can be solved in a matter of seconds, but do not provide the accuracy required. Fracture permeability and physics-based machine learning techniques is an area of active research, and a literature review of its applicability will be required. The work will use existing codes and datasets but will require the implementation of some numerical methods, and potentially learning new programming languages.
Expected outcomes and deliverables:	The primary aim of this project is to investigate the possibility of constructing a meta-model based on a modified Reynolds equation and training it on a large dataset calculated using high-fidelity methods (Navier-Stokes PDEs). Such a model would introduce a (potentially large) number of parameters, which would be found using back-propagation (i.e. adjoint method) techniques. The successful applicant will develop new skills in computational fluid dynamics, adjoint methods for optimisation, and data analysis.
Suitable for:	This project is open to students with a background in mechanical engineering, mathematics or applied physics. It is ideal for students that are interested in looking beyond the "machine learning" buzzword, and taking a deep dive into the realm of data-driven statistical and numerical methods, learning new things on the way.
Primary Supervisor:	Dr Christopher Leonardi
Further info:	This project will be co-supervised by Dr Lukasz Laniewski-Wollk (l.laniewskiwollk@uq.edu.au)

Project title:	**Dr Christopher Leonardi: Computational modelling of ferrofluidic flows for lab-on-a-chip applications**
Project duration:	10 weeks
Description:	The development of micro- and nano-fabrication techniques and advanced materials has supported some of the latest technology in smartphones and personal computing devices. In conjunction with this, lab-on-a-chip (LOC) and micro total analysis systems (mTAS) have grown in popularity and found a range of novel applications, including microreactors and biomedical devices (e.g. the treatment of retinal detachment). The use of a magnetic field to control individual ferrofluidic droplets is fundamental to the success of these LOC and mTAS devices. A ferrofluid, or ferromagnetic fluid, is a liquid that becomes strongly magnetised in the presence of a magnetic field.
Expected outcomes and deliverables:	The aim of this project is to develop a computational framework for simulating the behaviour of ferrofluidic droplets under controlled magnetic fields. This will involve the incorporation of Maxwell's equations in an existing computational multiphase fluid dynamics solver, which is based on the lattice Boltzmann method. The successful applicant will develop new skills in computational multiphase fluid dynamics, magnetohydrodynamics, and model development, verification and validation.
Suitable for:	This project is open to students with a background in mechanical engineering, mathematics or applied physics. Interest and demonstrated competence in fluid mechanics, computational fluid mechanics and applied mathematics would be of tremendous benefit to the project.
Primary Supervisor:	Dr Christopher Leonardi
Further info:	This project will be co-supervised by Dr Travis Mitchell (t.mitchell@uq.edu.au).

Project title:	**Dr Christopher Leonardi: Dynamics of mucus filled airways and its impact on acute respiratory distress**
Project duration:	10 weeks
Description:	With recent pandemics severely effecting the respiratory system, including SARS in 2003 and currently COVID-19, there is an obvious demand to understand the flow of fluids inside of airways. One potential form of infection occurs when the virus comes into contact with the mucus membrane that lines the human nose, mouth and eyes. The healthy cells present in this membrane allow the virus to multiply, infecting other nearby cells. This can cause swelling as a result of fluid and debris formation in the lungs. More serious cases can lead to pneumonia, in which the air sacs (alveoli) fill with mucus as the body attempts to fight the infection.
Expected outcomes and deliverables:	The aim of this project is to develop fundamental understanding of the mucus dynamics as it interacts with inhalation and exhalation processes, whether occurring naturally or ventilator-assisted. The study will make use of two-phase computational fluid dynamics to model the potential mucus displacement and or breakage in confined domains. The successful applicant will develop new skills in computational fluid dynamics, multiphase fluid mechanics, and model development, verification and validation.
Suitable for:	This project is open to students with a background in mechanical engineering, mathematics or applied physics. Interest and demonstrated competence in fluid mechanics, computational fluid mechanics and applied mathematics would be of tremendous benefit to the project.
Primary Supervisor:	Dr Christopher Leonardi
Further info:	This project will be co-supervised by Dr Travis Mitchell (t.mitchell@uq.edu.au).

Project title:	Effect of Nb-CVF on Abrasion and Fracture Resistance of NbC containing White Cast Irons
Project duration:	10 weeks
Description:	High-Cr white cast irons are particulate-reinforced composite materials in which a network of very hard (~1400 HV) chromium-rich carbides (M7C3) are supported by a moderately hard (~600 HV) matrix of martensitic steel. New research is exploring the potential for additional performance benefits by adding NbC, which is even harder (~1800 HV). A series of castings has been prepared with a wide range of volume fractions of NbC. Properties and performance will be evaluated using UQMP's innovative suite of industrially-realistic laboratory evaluation devices.
Expected outcomes and deliverables:	You will receive training in a variety of techniques for high-integrity laboratory research. You will generate data contributing to a large indistrially-funded research project. • Careful cataloguing and durable labelling of all specimens. • Accurate heat treatment to specified protocols; surface grinding to specified dimensional tolerances. • Measurement of Vickers hardness; Plot graph of hardness versus Nb-CVF (with appropriate treatment of statistical scatter). • ASTM G65 rubber wheel abrasion tests; Plot graph of abrasion versus Nb-CVF. This will provide perspective when industry partners enquire about results from "standard" test. • Making ready for conduct of ball mill abrasion test, ball mill edge-chipping test and inner circumference abrasion test, which will be performed by MECH4500 thesis students in 2021 sem 1.
Suitable for:	3rd-year student of Mechanical Engineering or related discipline. Materials knowledge desirable. Demonstrable work-ethic and attention to detail. Demonstrable skills in preparation of written reports.
Primary Supervisor:	Dr Jeff Gates
Further info:	Dr Yahia Ali (post-doc) y.ali@uq.edu.au

Project title:	What would be required for nuclear energy plants to be operating in Australia from the 2030s?
Project duration:	10 Weeks
Description:	A Preliminary Concept Study by the University of Queensland
Expected outcomes and deliverables:	A research report, including seven chapters, each chapter written by one research student. Each chapter has about 10 sub-sections. Each sub-section will need to be about 2 pages long (plus appendices). Each sub-section will require one week's research.
Suitable for:	Students should have an inquiring mind, interest in the topic, the ability to conduct research from secondary (and primary interview) sources; the ability to process and analyse structured and unstructured data and information; and the ability to work productively in a team with other research students. Knowledge and content skills from prior studies is a bonus.
Primary Supervisor:	Profess Stephen Wilson
Further info:	Contact Professor Wilson for the full project description and to have any questions answered: stephenjwilson@uq.edu.au