2019 UQ Winter Research Scholarship Program

Research Projects
offered by the
School of Mathematics and Physics (SMP)

How to apply:

The UQ Winter Research Program is offered by the School of Mathematics and Physics (SMP) and UQ Student Employability Centre during the winter vacation period (late June to late July). This document provides a list of available projects of interest to students undertaking mathematics, statistics and physics. It is open to undergraduate (including Honours) and masters by coursework students.

(1) Browse the list of projects.

(2) Contact the supervisor in the area of your interest, or the contact person listed, to discuss your interest and eligibility to undertake their research project. Gain the research project supervisor's tentative approval, and include this with your full UQ Winter Research Program application.

(3) Submit your application via StudentHub by closing date: **11.59pm, Friday 5 April 2019**.

UQ Winter Research Project Description

Project title: SMP-WRP-01-19	**Bacteria tracking and study**
Project duration:	6 weeks
Description:	Swimming modalities of many natural swimmers are not well understood. The aim of this project is trapping and tracking bacteria to study their swimming speeds depending on their environment. In particular, we aim to determine E.coli swimming forces and speeds in different viscous medium.
Expected outcomes and deliverables:	The Scholars will gain experience in handling and running optical systems, handling bacteria, and improving their skills in programming. The student will be asked to provide a written report of his/her work at the end of the project.
Suitable for:	The Scholars need to have a physics background with skills in programming such as Matlab.
Primary Supervisor:	Dr. Itia A. Favre-Bulle
Further info:	For more details on this project, contact e-mail is: i.favrebulle@uq.edu.au

UQ Winter Research Project Description

Project title: SMP-WRP-02-19	**Statistical physics model of abundances and interactions in plant communities**
Project duration:	Flexible, depending on the availability of the student. 4 – 10 weeks.
Description:	This project aims to use the methods of statistical physics to help understand the equilibrium and dynamics and of interacting plant communities with Prof Margie Mayfield in the School of Biological Sciences. Prof Mayfield's group has collected a significant amount of data on plant abundances, and shown that the data suggests that nonlinear interactions between the plants affect their seed production. We hope to gain a new understanding of this data using equilibrium models of statistical mechanics. See: Higher-order interactions capture unexplained complexity in diverse communities Margaret M. Mayfield & Daniel B. Stouffer Nature Ecology & Evolution 1, Article number: 0062 (2017) doi:10.1038/s41559-016-0062
Expected outcomes and deliverables:	Hopefully we will show that physics methods can be used to help understand the interactions between plants in a community.
Suitable for:	Self-motivated science students with strong quantitative skills who are interested in pursuing an interdisciplinary project covering theoretical physics and biology. Knowledge of statistical mechanics is desirable.
Primary Supervisor:	Professor Matthew Davis / Professor Margaret Mayfield
Further info:	Please get in touch with Professor Davis before applying for this project. mdavis@physics.uq.edu.au

UQ Winter Research Project Description

Project title: SMP-WRP-03-19	**Nonequilibrium superfluid flows**
Project duration:	Flexible, depending on the availability of the student. 4 – 10 weeks.
Description:	The aim of this project is to make a connection between classical mechanics and quantum mechanics - looking for the signatures of classical trajectories in the quantum wave functions. This is potentially interesting for superfluids, as to some extent they behave as classical fluids. This would require adding the effects of particle interactions - an additional nonlinear term in the Schrodinger equation.
Expected outcomes and deliverables:	Students will learn how to solve the linear and nonlinear Schrodinger equation computationally with sources and sinks. The results may influence the UQ experimental program on Bose-Einstein condensates.
Suitable for:	Self-motivated science students with strong quantitative skills who are pursuing research in theoretical and computational quantum physics.
Primary Supervisor:	Professor Matthew Davis
Further info:	Please get in touch with Professor Davis before applying for this project. mdavis@physics.uq.edu.au

UQ Winter Research Project Description

Project title: SMP-WRP-04-19	**Deep learning enhanced tracking of molecular bonding**
Project duration:	4 weeks
Description:	At sub-cellular scale, biological systems seethe with motion, from the motor molecules that transport nutrients along microtubules to neurotransmitter receptors the motion of which is important for neural plasticity. Measurements that track the motion of biological targets and their interactions over time are crucial, and widely used to understand these important processes. However, the clutter of organelles and other components in a biological specimen often make it challenging to effectively and accurately track targets. This project will employ deep learning approaches to train a neural network to distinguish the target from the clutter, and therefore improve our ability to track biological dynamics.
Expected outcomes and deliverables:	The scholar should expect to learn about machine learning and artificial intelligence. Most specifically, how to apply deep learning algorithms to train a neural network to out-perform conventional methods of imaging analysis. The scholar should, further, expect to learn the state-of-the-art in approaches to track biological targets. Should the project be successful, it may result in a peer-reviewed publication.
Suitable for:	This project is open to year 2-4 students with a background in physics and with a solid foundation of programming in Matlab.
Primary Supervisor:	Professor Warwick Bowen
Further info:	Applicants would be encouraged to register their interest to Prof Bowen to applying: w.bowen@uq.edu.au

UQ Winter Research Project Description

Project title: SMP-WRP-05-19	**Nonlinear dynamics in a quantum fluid**
Project duration:	4 weeks
Description:	This project will investigate fluid dynamics in superfluid helium, a fluid with esoteric quantum properties including flow without dissipation and quantised vortices. The project will experimentally test the idea that nonlinear interactions are required to understand the fluid dynamics, and lead to interesting phenomena such as solitons.
Expected outcomes and deliverables:	The scholar will gain skills in Nanophotonic experiments, analysing the data they produce, and in simulation of nonlinear dynamics.
Suitable for:	This project is open to year 2-4 students with a background in physics and with a solid foundation of programming in Matlab.
Primary Supervisor:	Professor Warwick Bowen
Further info:	Applicants would be encouraged to register their interest to Prof Bowen to applying: w.bowen@uq.edu.au

UQ Winter Research Project Description

Project title: SMP-WRP-06-19	**Structural optical imaging of single molecules**
Project duration:	4 weeks
Description:	Every cell in your body contains millions of motor molecules. The ability to image their structure and how they move, is a grand cross-disciplinary challenge. This project will develop a new technique to optical image the structure of single molecules by taking advantage of the structure-dependence of the optical polarizability.
Expected outcomes and deliverables:	The project will develop computational tools to calculate the polarisability of molecules from their structure. It will apply those techniques to predict measureable signals due to molecular dynamics, and to investigate the effect of the polar nature of surrounding water on these signals.
Suitable for:	This project is open to year 3-4 students with a background in physics and with a solid foundation of programming in Matlab.
Primary Supervisor:	Professor Warwick Bowen
Further info:	Applicants would be encouraged to register their interest to Prof Bowen to applying: w.bowen@uq.edu.au

UQ Winter Research Project Description

Project title: SMP-WRP-07-19	**Analyses of experimental data in fractured specimens**
Project duration:	4 weeks
Description:	Fracture initiation and propagation is an important aspect of material failure. In some cases, i.e. brittle materials, structures fail with loads much below the one given by their strength due to the presence of notches and cracks that initiate fracture. Several theories and numerical models are currently proposed in the literature to obtain estimates of failure loads in structures where fracture is present.
Expected outcomes and deliverables:	The students will be exposed to the latest scientific trends in the study of fracture initiation and modelling of fracture processes. They are expected to confront recent experimental data with the current leading theories and modelling techniques, and then critically evaluate how the current state of knowledge can provide accurate justification of the data.
Suitable for:	Students with an interest in applying their mathematical skills to a real world problem.
Primary Supervisor:	Dr Matías Benedetto - m.benedetto@uq.edu.au
Further info:	

UQ Winter Research Project Description

Project title: SMP-WRP-08-19	**Bi-exponential synaptic effects on neural adaptation**
Project duration:	4 weeks - QIMR Berghofer Medical Research Institute, Herston
Description:	This project will investigate the effect of a bi-exponential synaptic input function on the spike adaptation property of a neural network. By exploring the advantage of a double decay feature, the bi-exponential model has been showed to have an obvious statistical superiority for kinetic analysis of relaxation mechanism. Thus, the bi-exponential waveforms are more realistic representations of the conductance change at a typical synapse, resulting in a more accurate description of the neural adaptation mechanism crucial to the understanding of pathological neural disorders such as epilepsy.
Expected outcomes and deliverables:	Applicant will acquire skills in modelling and computational science related to neural dynamics, while improving the current understanding of how the brain adapt to responses and investigating the connection between this and certain neuropathological disorder such as epilepsy.
Suitable for:	The project is suitable for Honours and Master students.
Primary Supervisor:	Dr James Roberts, Dr Davids Agboola Davids.Agboola@qimrberghofer.edu.au
Further info:	Students MUST contact the supervisor prior to submission of an application.