# Mech Connect

## Department of Mechanical Engineering Annual Report 2023

UNIVERSITY OF CANTERBURY
*Te Whare Wānanga o Waitaha*
CHRISTCHURCH NEW ZEALAND




UNIVERSITY OF CANTERBURY | Engineering Pūhanga

# Contents

**The department of Mechanical Engineering remains in the top 300–350 Mechanical Engineering department worldwide in the QS ranking. It is ranked second in New Zealand.**

# Head of Department

## Kia ora,
## Welcome to the 2023 edition of Mech Connect Annual Report

I hope you will enjoy reading this annual report which will give you a glimpse of our department in 2023 and is an opportunity to celebrate its many successes.

The absence of COVID-related disruptions and the return to a more conventional mode of delivery of our curriculum have been welcome by staff and students alike.

2023 marked the 150th of the University of Canterbury and it was a pleasure to reconnect with many friends and alumni of the department at an event held at UC in October. The previous alumni event dated back to 2019.

On one hand, I think it is fair to say that our department has evolved a lot since 2019. Our total student number has grown by 25% since 2019 and we have registered a record interest for our program in 2024, a fortunate position to be in. I strongly believe that the high demand for our program reflects the quality of the degree we offer and the range of rewarding careers it gives access to.

So, I would like to take this opportunity to express my gratitude to the staff of the department whose dedication is critical to the student's experience and the quality of our graduates. I also would like to acknowledge the alumni & friends of the department who create many of the opportunities for our students.

A special thank also to the members of our Industrial Advisory Board whose input over the years is so valued.

In the past year, we have also created new pathways for our students such as the brand-new Master of Aerospace Engineering or Conjoint degrees which will equip our future graduates with additional skills and knowledge in management, sport, or health science, for example. The goal of these new pathways remains to train strong Mechanical Engineers but with a distinctive flavour.

On the other hand, some things have remained the same in the department because they are part of its core fabric.

We remain committed to Research & Innovation. Prime examples of the exciting research occurring in our department are included in this report.

We still are strongly committed to the students "learning by doing" and an example of this is our second-year students wining emphatically the Warman design competition in 2023.

Final year projects are a critical part of our curriculum, and this annual report presents a selected few. They are so important to the development of our students as they give them a glimpse of the real life and work of engineers.

I take this opportunity to thank our Final Year Project sponsors in 2023.

Lastly, I could not reflect on the successes of the department without talking about the clubs. Mechanical Engineering is heavily invested in several student driven club because they provide students with unique experiential and peer-to-peer learning. Every year, I am amazed by what the students achieve as part of clubs like UC Motorsport, UC Aerospace, UC Biomed. These clubs have existed for a long time, but 2023 brought new ones like Human Power vehicle club or the UC Sustainable Design Club. They often compete overseas and make the department proud. One of the many highlights is UC Motorsport winning the Formula Student competition in December 2023 and ranking 3rd worldwide, putting UC Mech in the spotlight.

Thank you to all the readers for your interest in our department. I hope you enjoy the read in this annual format. Remember to stay connected and share your stories with us in 2024.

*Prof Mathieu Sellier,*
*Head of Department – Mechanical Engineering*

# Who Are We

# Staff Members

## Academic staff

Mathieu Sellier
Professor
Head of Department – Mechanical Engineering

Geoff Rodgers
Professor
Deputy Head of Department

Sid Becker
Associate Dean (International, Postgraduate)

Geoff Chase
Distinguished Professor
Advisor to Students with Disabilities

Catherine Bishop
Professor

Don Clucas
Associate Professor

Paul Docherty
Professor
Director of Studies 2nd Year Engineering

Tim Giffney
Director of Postgraduate Studies (PhD)

Shayne Gooch
Associate Professor Director of Studies 3rd Year Engineering

Stefanie Gutschmidt
Associate Professor
Chair of Outreach & Marketing

Mark Jermy
Professor
Director of Postgraduate Studies (ME)

Natalia Kabaliuk
Senior Lecturer
International Director of Studies

Milo Kral
Professor
Industry Liaison

Deborah Munro
Associate Professor

John Pearse
Associate Professor
Undergraduate Director of Studies

Dirk Pons
Professor

Chris Pretty
Professor
Co-Director of Mechatronics

Mark Staiger
Associate Professor
Chair of Departmental Research Committee

David Denkenberger
Associate Professor
Director of Studies 4th Year Engineering

Digby Symons
Associate Professor
Director of Final Year Research & Development Projects

Malcolm Taylor
Lecturer

Yilei Zhang
Associate Professor
Director of Master of Engineering Studies

Dan Zhao
Professor

James Hewett
Lecturer

John Cater
Professor

Stephen Daynes
Senior Lecturer

## Administrators

Emma Buck
Administrative Services Manager

Jess Daly
Administrator

Greta Rapalaviciute
Administrator

Penny Crudgington
Administrator

## Senior Tutors

Christine Walker
Senior Tutor

Tania Shuker
Senior Tutor

George Stilwell
Senior Tutor

## Post Doctoral and Research Associates

Bushra Anam
Post Doctoral Fellow

Bradley Boyd
Post Doctoral Fellow

Jennifer Knopp
Post Doctoral Fellow

Anqi Gu
Post Doctoral Fellow

Nay Lin Oo
Post Doctoral Fellow

Jessica Fitzjohn
Post Doctoral Fellow

Jake Campbell
Post Doctoral Fellow

Steven Su
Post Doctoral Fellow

## Technical and General Staff

Bruce Robertson
Technical Services Manager
Design Engineer

Tony Doyle
Staff Workshop Team Leader

Dr Bill Mohs
Project Engineer
(Thermodynamics and Fluid Dynamics)

Rodney Elliott
Technical Officer
Scientific Officer

Adam Latham
Systems Administrator
Technical Officer

Garry Cotton
Technician
Workshop Training Team Leader (UC workshops)

Dr Shaun Mucalo
Projects Engineer –
Microscopy and Materials

Julian Phillips
Technician
Technical Officer

Zac Perston
Projects Engineer

Paul Southward
Programmer Analyst
Systems Analyst /
Programmer

David Read
Technical Officer

David Fanner
Workshop Technician

Dr Oscar Torres
Project Engineer

Owen Kelly
Project Engineer

Antony Doyle
Workshop Technician

**Retirement/resignation:**

- Jess Lagoutte (Administrator) – since February 2023
- Tony Zhou (Post Doctoral Fellow) – since June 2023

**New Onboard**

- Owen Kelly (Project Engineer) – since May 2023
- Greta Rapalaviciute (Administrator) – since April 2023

**Erskine visitors:**

- Professor Gary Shiflet (University of Virginia) – ENME481S1 Special Topic: Materials that Shape Civilizations
- Professor Wylie Ahmed (California State University Fullerton) – ENME451S2 Biomechanics
- Associate Professor Jay Warren McMahon (University of Colorado Boulder) – ENME427 Engineering Failure Analysis and Prevention

# Postgraduate Students

Our department continues to engage with top postgraduate students in various research areas. Our postgraduate student body in 2023 consisted of 31 Masters and 82 PhD students (31 December 2023). The department is proud of actively pushing the boundaries in a variety of fields including bio-medical, robotics, renewable energy, materials science, design, and solid and fluid-dynamics engineering. We are pleased to report that in 2023, we have seen another increase in our postgraduate enrolment numbers.

## PhD completions

**Ali Mohammadi Sefidan:** *Drying kinetics of milk droplets in spray dryers: a tripartite modelling approach*. Supervisor: Mathieu Sellier

**Tao Cai:** *Systematic Investigations on Flame Propagation, Reaction Mechanism Reduction, Combustion and Emission Characteristics in Ammonia-Fueled Micro-Combustors*. Supervisor: Dan Zhao

**Florent Struyven:** *Study of electrogenerated two-phase and microfluidic flows*. Supervisor: Mathieu Sellier

**Benjamin Murton:** *Methods for the creation of high performance cellular materials*. Supervisor: Digby Symons

**Qianhui Sun:** *Digital Twins in Mechanical Ventilation: Models, Identification, and Prediction of Patient-Specific Response to Care*. Supervisor: Geoff Chase

**Raghu Ande:** *A Theoretical and Numerical Investigation of Large array of Cantilever Beams in Fluids*. Supervisor: Stefanie Gutschmidt

**Paul Stephenson:** *Modelling Multi-Component Nucleation and Growth of Aerosol Droplets in an Inhaler Device*. Supervisor: Mark Jermy

**Hosea Watson:** *Brain-inspired spiking neutral network for tactical signal processing*. Supervisor: Yilei Zhang

**Sia Nourani:** *Applications of virtual manufacturing to classify and assess the feasibility of clinching process with respect to mechanical properties of materials*. Supervisor: Dirk Pons

**Jinshen Tong:** *Numerical investigation on enhancing thermal performance and flame stability of a micro-combustor in thermophotovoltaic power systems*. Supervisor: Dan Zhao

**Jennifer Ormsbee:** *Modelling endogenous glucose production and glucose uptake in human health and disease*. Supervisor: Geoff Chase

**Arash Bagheri:** *Optimum Handle Location for the Hand Assisted Sit to Stand Transition: A Tool*. Supervisor: Keith Alexander

**Zichong Lyu:** *Optimisation of freight transportation networks – Supply Chain Modelling of Modal Mixes and Network Configurations for Optimisation on Measures of Cost, Lead Time and Sustainability*. Supervisor: Dirk Pons

**Theodore Lerios:** *Nonlinear Respiratory Airway Resistance and Breathing Effort Estimation for Respiratory Disease Monitoring and Care*. Supervisor: Geoff Chase

## Master's completions

**Benjamin Hull:** *Flight Trajectory Modelling and Flight Path Prediction of an Unmanned Aerial Vehicle for the New Zealand Defence Force and the Defence Technology Agency*. Supervisor: Paul Docherty

**Jeremy Whiting:** *Design of a Deployment and Retrieval System for Submerged Open-Ocean Aquaculture Structures*. Supervisor: Shayne Gooch

**Vincent Massé-Denicourt:** *Additively Manufactured Rocket Thrust Chambers: Damage Characterization Post Hot-Fire and Material Properties*. Supervisor: Milo Kral

**Joseph Lynch:** *The response of wilding pine samaras to perturbation as experienced in turbulent wind conditions*. Supervisor: Mark Jermy

**Christian James:** *Temper Bead Welding Procedure Development*. Supervisor: Milo Kral

**Chunming Jaung:** *Structure-Property-Processing of Additively Manufactured Aerospace Alloys*. Supervisor: Milo Kral

**Jonty McMillan:** *Development of Elastic Lattice Structures Suitable for Rugby Headgear*. Supervisor: Natalia Kabaliuk

**Reid Williams:** *Collection efficiency of pesticide spray samplers in forestry*. Supervisor: Mark Jermy

**Samuel Plummer:** *Assessment of Microstructural Modification Methods for Cast CuSn12Ni*. Supervisor: Milo Kral

## New PhD students enrolled in 2023

**RCaleb Barr:** *How can the RoC*RoI model be adapted to advance predictive power and fairness*

**Finn Birchall:** *Accelerating Alloy Discovery through Gradient Microstructures*

**Phillippe Bruneau:** *Development Of A Method For Evaluating The Sustainability Of Energy Systems*

**Jaimey Clifton:** *Classification and predictive monitoring of respiratory disease*

**Sam Dougherty:** *Investigations into the unsteady aerodynamic performance of low Reynolds number multirotor UAVs: theoretical, experimental and numerical*

**Isaac Flett:** *Quantifying Agitation in Intensive Care Patients Using Wearable Devices*

**Congyu Xu:** *Development of TPMS structures suitable for rugby headgear*

**Tambwe Gregoire Mbangu:** *Application of systems dynamics to determine manufacturing scenarios for transition to Environment 4.0 and Industry 4.0*

**Alexandra Mckendry:** *Resonant MEMS for in-sensor reservoir computing*

**Theo Nankivell:** *Cavitation Mitigation on Hydrofoils by Surface Distributed Mass Flux*

**Han Qiao:** *Empowering Enterprise Product Emotional Design with AI: Integrating Kansei Engineering and Large Language Models for Human Emotion Recognition*

**Kaspar Soltero:** *Acoustic Resolution of Animal Dynamics for Informing Biosecurity in Old-Growth and Regenerating Native Forests*

**Widhanalage Ramesha Indeewarie (Ramesha):** *Soysa Sensor System to Measure and Monitor Stress Fractures in Racehorses*

**Annette Swale:** *Investigating the Efficacy of Innovative Design Approaches for Softshell Headgear to Minimise the Intensity of Head Impacts in Youth Rugby Players*

**Prospero Uybarreta:** *A Limited Study to Develop a Piloted Aircraft Comprehensive Operability Rating System (PACORS)*

**Kritika Khanal:** *Interface Phase Transition and Degradation in Pb-free Ferroelectric Ceramics*

**Ana Luisa Monteiro:** *Production of plant-based resilient foods in case of catastrophe*

**Junfeng Wu:** *Construction of a novel probiotics encapsulated delivery pathways with prebiotic materials*

**Kamean ali Ahmed:** *Towards lower costs and reduced waste in 3D printing using functionally graded lattice structures*

## PhD students enrolled in 2023

**Adam Cox:** *Optimal control of flow over a hydrofoil using suction/blowing to mitigate cavitation*

**Aditya Avinash Joshi:** *Modelling the mechanochemical performance of biodegradable magnesium alloys*

**Alexander Declan McHugh:** *Biomedical modeling and mechatronics*

**Andres Carlos Guiguet:** *Sustainable and resilient supply chains: A New Zealand simulation-based design*

**Andrew James Garner:** *Productivity of organisations*

**Andrew Lange:** *Modelling collisions of milk droplets*

**Ben McEwen:** *Audio Visual Classification and Interactions with Invasive Predator*

**Benjamin Murton:** *Methods for the creation of high performance cellular materials*

**Christopher Cameron:** *Direct nerve interface for control of assistive devices, using sieve electrodes*

**Chunming Jiang:** *Brain-inspired spiking neutral network for tacticle signal processing*

**Connor Melton:** *Optimising Plantar Heel Pain Comfort with User Adjustable Home Footwear*

**Dael Summerhays-Sunnex:** *Mechatronics based virtualisation of ASD emotion recognition therapy*

**Dale Cusack:** *An experimental investigation of lava rheology using analogue fluids and numerical methods*

**Daniel Morris:** *Modelling and control of miniature aerial vehicles in proximity to structures*

**Danyon Stitt:** *Concussion in rugby: investigating the biomechanics and means of reducing mTBI in rugby players.*

**David Muchiri:** *Inference of Effective Rheological Laws for Shallow Lava Flow Models from Surface Movements*

**Di Guan:** *Attenuating Self-Excited Thermoacoustic Instability in Rijke-Type Combustors by Implementing Bias Flow Perforated Liners"*

**Ella Guy:** *Rehabilitation of Continuous Positive Airway Pressure (CPAP) Ventilation*

**Emily Young:** *Point-of-Care Biomolecule Sensor Technology Platform for Measuring Insulin*

**Finn McIntyre:** *Spin-Coating on Curved Surfaces*

**Hamish Ferguson:** *Modelling of Road and Track Cycling demands and Cyclist characteristics using Power Meter Data to enhance Competition Performance*

**Hammad Mohsin:** *Bioelastomeric meshes: processing, structure and properties*

**Haoyu Cheng:** *Numerical investigation on trapped vortex combustion*

**He Zhao:** *Numerical Studies on Micro-Combustion*

**Honey Gupta:** *Processing structure relationships of tannin-loaded protein based aerogels: Pore structure, molecular interation and tannin release kinetics*

**Hui Rong:** *Portable fuel cells are attracting more attention in the development and application of emergency power generator system*

**James Cushway:** *Model-Based Fluid Resuscitation in the Intensive Care Unit*

**Jessica Rocio Montoya Meja:** *3D Printing of Piezoelectric Transducers*

**Josie Dixon:** *Narrow-Band Optical Methods For Blood Analyte Detection*

**Kaleb McGillivray-Seaton** *Wireless Power Transfer and Communication Development for High-Depth Miniaturised Biocompatible Implants*

**Kathryn Ford:** *High Temperature Molten Oxide Electrolysis to Produce Metals*

**Kong Ting Lee:** *Smart agriculture decision support system*

**Lachie Crawford:** *An Autonomous Monocopter for Fighting Fires*

**Lev Chernyshev:** *Improving real-time hydrodynamic models of foiling yachts in dynamic simulation*

**Linghui (Jeff) Meng:** *EMG-EEG hybrid system to improve recognition accuracy of hand gestures based on deep learning*


*April 2023 Graduation. PhD students at Toki ceremony together with undergraduates, whanau and friends.*

**Lixian, Guo:** *Numerical and experimental studies on standing-wave thermoacoustic engines*

**Maria Isabel Andrade Beltran:** *Energy intervention design and implementation focused on human behaviour towards a shift in energy use from HVAC systems in commercial buildings*

**Matthew Payne:** *A low cost, open source insulin pump and non invasive CGM, controllable via any bluetooth enabled smartphone, for the improvement of diabetes care*

**Mohammad Sagor Hosen:** *3D printability of recycled semi-crystalline polymers*

**Molly Evans:** *Numerical and Experimental Investigations on Thermoacoustic Instability in Ammonia-Fired Gas Turbine Combustors*

**Nicholas Lam:** *Advancing numerical evaluation of model identifiability in noisy data*

**Nicolas Davey:** *Predictive Cardiovascular Modelling using Support Vector Machines*

**Nina Pernus:** *Research in Instrumented Sport Climbing Holds*

**Paul (Pavlo) Kyselvo:** *Non-destructive testing of products made of polymer composite materials: Research and development of control technology*

**Pavithran Devananthan:** *Response of brain tissue to cyclic loading that mimics rTBIs*

**Prospero Uybarreta:** *A Limited Study to Develop a Piloted Aircraft Comprehensive Operability Rating System*

**Ramesha Soysa:** *Micro-fabricated Sensor System to Measure and Monitor Stress Fractures in Racehorses*

**Rebecca Helene Kehela Emanuel:** *Using Machine Learning to Further PCOS Research*

**Reza Kordani:** *Design of Building System with Rocking Frame/Wall*

**Richard Ellingham:** *Novel dielectric elastomer actuators for biomedical rehabilitation applications*

**Ross Geoffrey Shepherd:** *Optimal control of the spin coating process*

**Salma Radwan Mohamed:** *Heat transfer correlation for expansion regime pulsed pressure mass transport*

**Samaneh Dashti Ghalehjogh:** *Application of Energy Dissipation Devices to Steel Jacket Structures*

**Seigan Hayashi:** *Extending Control-Based Continuation Methods for Dynamical System Analysis*

**Simon Blue:** *Novel Long-Term Packaging Material for Wireless Implantable Devices*

**Thomas Bell:** *Research and Development of On-Orbit Servicing Capability for Dawn Aerospace Propulsion Systems*

**Thomas Maslin:** *Active, coupled micro-oscillators for totally implantable*

*Trudy Calje-van der Klei: Computational lung mechanics virtual patient modeling*

**William Rangi:** *The Design and Modification of Honeycomb Structures to Increase Formability in High Curvature Applications*

**Xinyu Zhao:** *Theoretical and Numerical Studies on Combustion Instability and its Control*

**Xiran Liu:** *Study of the Efficient Use of Small-Scale Wind Harvesters under Different Conditions and the Properties of Wake Flow*

**Yiheng (Gwen) Guan:** *Numerical and Theoretical Investigations on Nonlinear Thermoacoustic Instabilities in a Bifurcating Combustor and Flame Transfer Function*

**Yufeng Lin:** *3D printing of complex food structure*

**Zhi Sun:** *Developing bio-inspired artificial intelligence based on thermodynamics'*

**Ziqi Dai:** *Design of highly swept propeller blades*

## NEW Master's students enrolled in 2023

**Augusta Collet:** *Investigating the viability of sub soil irrigation for Canterbury arable agriculture*

**Dylan Cameron:** *Development of a system for feature cost estimation system for informing early design decisions*

**Campbell Stevens:** *Development of a Sustainable Alternative to Current MBBR Carrier Media*

**Ekaterina Lieshout:** *Sit Ski Research Project*

**Jordan Smith:** *Deep Learning Approach for Improving Emotional Recognition Skills for Individuals with Autism Spectrum Disorder: Development of Foundational Technology*

**Finn Peterson:** *Investigation into the Efficacy of an Adaptive Aerofoil System on Multirotor Drones*

**Kailin Paul:** *Mobile robotics – snake robot*

**Zane Goggin:** *Computational fluid dynamics of upper airway during optiflow+ duet asymmetric interface nasal high flow therapy*

## Master's students enrolled in 2023

**Andrew Garner:** *Manager worker relationship in industrial operation. Personal productivity and its contributions to national productivity: A New Zealand – Denmark contrast*

**Alexander Towse:** *The modelling of muscle fatigue during electrical stimulation using bio-signals for the management of muscle fatigue during stroke rehabilitation with a hybrid assist-as-need exoskeleton*

**Baxter Williams:** *Market-Based Management of Electricity Demand for Sustainable Electrification of Vehicles, Homes, and Businesses in Aotearoa New Zealand"*

**Benjamin Hull:** *Analysis and modelling of a high-altitude UAV to sample airborne volcanic ash.*

**Caleb Ibbotson:** *Investigating the Viability of Using Machine Learning as a Method of Optimizing the Gait of An Existing Planar Snake Robot Characterization Post Hot-Fire and Material Properties*

**Dylan Cameron:** *Development of a system for feature cost estimation system for informing early design decisions*

**Francis Pooke:** *Low-cost mechanical insulin pump design and validation*

**Gordon Lay:** *Noodle: A compliant, re-configurable 3D serpentine robot*

**Hayden Leete:** *Simulating racket sport haptics for exergames*

**Hosea Watson:** *Process-Structure-Property Relationships of Additively Manufactured Aerospace Alloys*

**Jack Davies:** *Design, development and testing of high aspect ratio solid rocket motors for sounding rockets*

**James Sinclair:** *Investigation of intra-patient and inter-patient variability for synchronised acoustic emission and lower-limb biomechanics data for total hip replacement patients.*

**Jeremy Whiting:** *Open Ocean Aquaculture Depth Management System*

**Jinshen, Tong:** *Using numerical simulations to characterize the combustion instabilities occurred in cavity-stabilized scramjet combustors, in order to get insights on the origins and control mechanisms of combustion oscillations.*

**Mackenzie Caughey:** *Creep Ratchetting of Steam Methane Reformer Tube Alloy*

**Marcus Taylor:** *Investigating the process of 3D printing piezoelectric composite materials, their properties and applications as advanced sensors, and potentially as actuators.*

**Mariah McDonald:** *Extending predictive pulmonary models to a wider demographic*

**Matthw Durrant:** *Prevention of cavitation over hydrofoils using suction and blowing of the boundary layer through porous media*

**Olaf Manz:** *Stress Corrosion Cracking of Commercial Bronze and Brass*

**Paul Stephenson:** *Modelling the Growth and Deposition Patterns of Liquid Inhaler Droplets in the Human Airway*

**Qianhui Sun:** *Predictive, Patient-specific MV Virtual Patients Model for Sedated Patients and Assisted Spontaneous Breathing Mode*

**Richard Wiley:** *The Effect of Thermomechanical Processing Parameters on the Texture of Ti-6Al-4V Forgings as a Precursor to Abnormal Grain Growth*

**Simon Reid:** *High-performance 3D-printed catalysts for green spacecraft propulsion*

# Undergraduate Students

The Mechanical Engineering Department continues to attract undergraduate students, as evidenced by the record enrolment numbers in both Mechanical (Mech) and Mechatronics (Tron) Engineering.

In 2023, 156 students enrolled in the second year of Mechanical Engineering and 117 students enrolled in the second year of Mechatronics Engineering. Additionally, Mechatronics Engineering has experienced a substantial increase in enrolment, with current numbers nearly double those from just five years ago.

*Teaching of a lab class.*

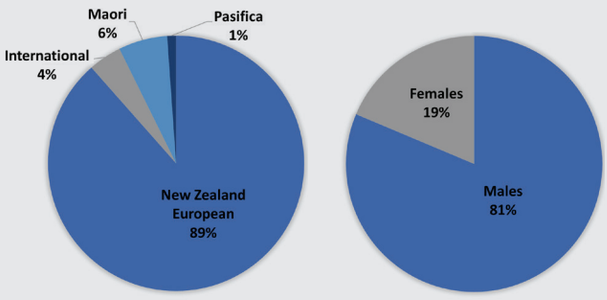
*FYP presentation day 2023.*

## Cohort diversity

The number of Māori/Pasifika students has had a moderate growth over recent years but UC's strategy aims for strong growth & retention going forward. The corresponding Faculty KPI aims for 49% growth of Māori students and 94% growth of Pasifika students by 2026.

The Mechanical Engineering incoming cohort observes a steady number of female students which has grown since our lowest in 2013. Female students now represent ~20% of the cohort, a number which we would like to continue increasing going forward. Initiatives to improve gender balance:

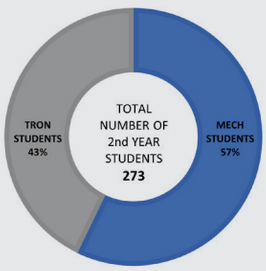
- Invite students from Villa Maria (all-girl school in Christchurch) interested in engineering to visit the department and outreach to West Coast high schools
- New Scott Technology undergraduate scholarship for female students
- Participation in the Woman in Engineering summer residential program




*Mechanical Engineering 2nd – 4th Year 2023*

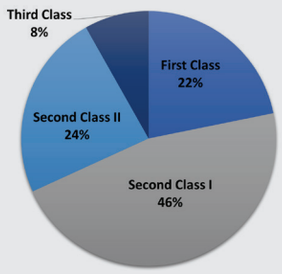
## Mech/ Tron students 2023

- 156 students joined 2nd year Mechanical Engineering in 2023.
- 117 students joined 2nd year Mechatronics Engineering in 2023.




## Students performance

The average GPA of incoming students in 2023 was 6.2 for Mechanical Engineering. The average GPA has steadily increased in the past 2 years as a consequence of the increased demand for our program. Another important consequence of the increased selection for Mechanical Engineering students is the number of students with a very low GPA has decreased.




*Honours split in Graduate Students 2023*

# Teaching

# Teaching & Learning

The Teaching & Learning Committee (TLC) was led by Chair A/Prof John Pearse and its team members were: John Pearse (Chair), Paul Docherty, Shayne Gooch, David Denkenberger, Natalia Kabaliuk, Tim Giffney, Geoff Rodgers (HoD nominee), Christine Walker, Tania Shuker, Jess Daly.

In 2023, 168 students expressed their interest in enrolling the BE (Hons) Mechanical Engineering Programme, which required a selection process to put in place based on first year academic performance. This highest ever number of students required some changes to our processes and methods in several areas of our activities. The Department also welcomed seven international students within the framework of UC's study-abroad programme and started the development of standard courses/programmes at identified exchange universities.

The Department offered nine elective courses (or short *Electives*) for students in their final year of study. These included a new course, *Flight and Spaceflight Mechanics* (ENME488). This is a further and fifth elective towards the Aerospace Minor, established in 2022. Regarding elective courses, the trend over the last few years has been an increase in numbers in aerospace related electives (Aerodynamics and Ground Vehicle Dynamics (ENME404) and Aerospace Propulsion (ENME460)) at the expense of thermodynamic related electives (ENM405, ENME465 and ENGR401). There has been a small decline in the number of students doing materials related electives.

A **communications skills programme**, implemented in ENME201, ENME215, ENME203; ENME301 and ENME408 years two and three was further developed and extended to fourth-year students. The programme includes written, oral, visual and teamwork skills for academic and professional environments.

A **conjoint degree structure** was developed for implementation in 2024. The conjoint degree is offered with several other qualifications including Bachelor of Commerce, Bachelor of Health Science, Bachelor of Data Science and Bachelor of Product Design.

The TLC continued to work on building community in the undergraduate cohort. This included developing inductions for the second, third- and fourth-year cohorts and continuation and extension of the **Mech Mentors programme** for second year students. Progress was made relating to accessibility issues for differently abled students and this is continuing.

# Master of Aerospace Engineering

Aerospace is a growing sector in Aotearoa New Zealand, with UC uniquely placed in Waitaha Canterbury as the centre hub and testbed for industry.

The new Master of Aerospace Engineering (MAerospaceEng) programme, approved this year, provides the opportunity to explore and complete research in designing, testing, and building aircrafts and integrated systems.

The MAerospaceEng programme is made up of 180 points, which includes 60 points of aerospace engineering courses and a 120 points thesis on an aerospace engineering topic.

MAerospaceEng programme includes the following:

Taught courses in aerospace engineering of one's choice, from dynamic atmospheric conditions to autonomous vehicles to rocket design.

An original thesis with an aerospace engineering topic.

Use of UC's on-campus facilities for experiments, testing, and computations, e.g. our Structural Engineering Lab, Advanced Manufacturing Lab, Wind Tunnel Facilities, AR/VR suite, and others.

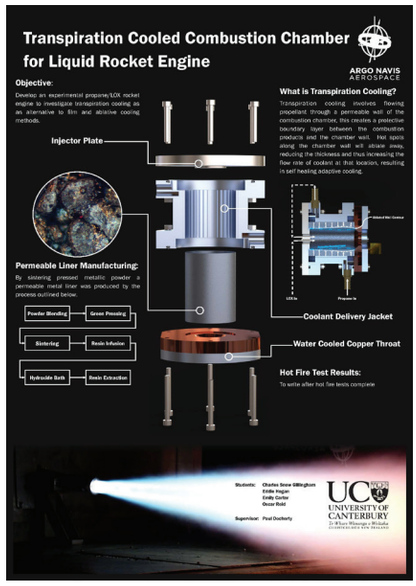
Industry connections through project work and visiting experts.

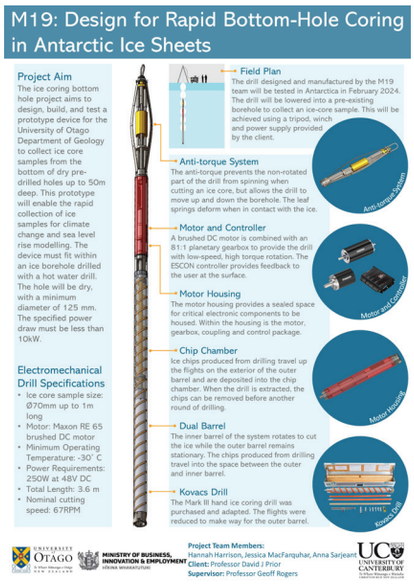
Beginning in either February or July, the degree will take 18 months of full-time study to complete, or part-time up to 3 years. Please contact the Department of Mechanical Engineering for more information.

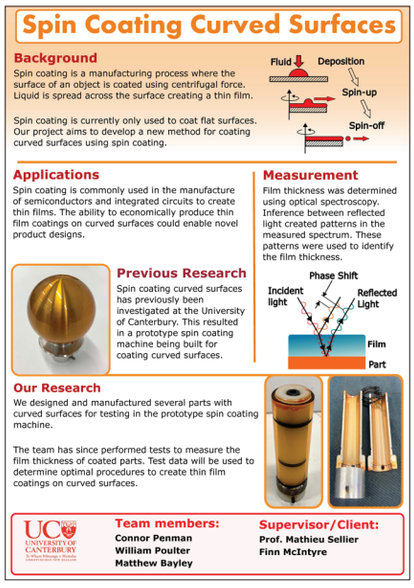
*UC Aerospace club's rocket launch.*

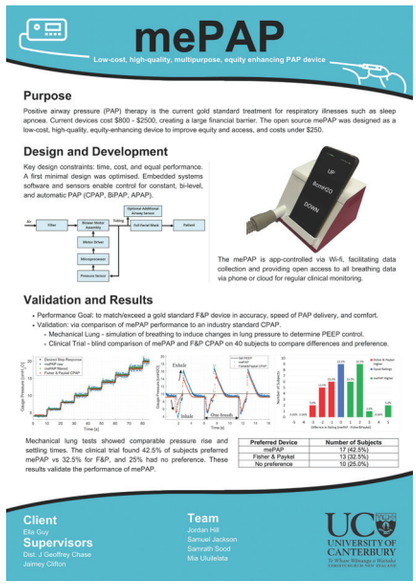
# Final-Year Industry & Research Projects

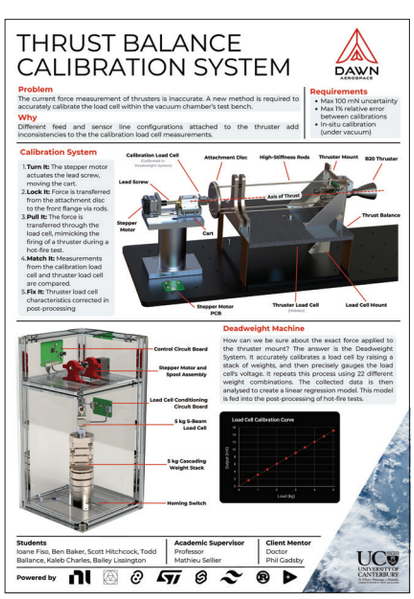
In 2023, students in the Department of Mechanical Engineering completed a total of 46 final projects (FYPs), which means the numbers continue to rise. For comparison, there were 43 projects in 2022, 42 in 2021 and 34 in 2020. Out of these, 28 projects were sponsored by 20 external organizations, while 7 were sponsored by research grants, 10 internal Mech Eng projects (UC Motorsport, UC Aerospace, UC Human Power, SAE Aero Design) and one for a non-profit organisation. The main focus areas of these projects included the design and development of equipment for the agricultural and food industry, advancements in automotive technology, sports engineering, design of assistive devices for people with disabilities, aerospace, and biomedical engineering.

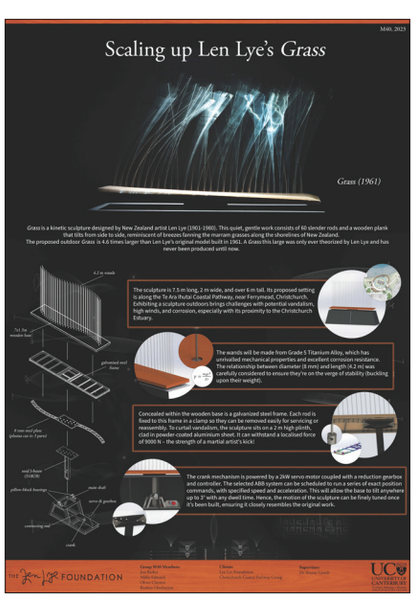




# Clubs

## UC Aerospace

In 2023, the UC Aerospace Club had an exceptional year, with the crowning achievement being the club's victory in the fiercely competitive 30K COTS Category at the Spaceport America Cup, distinguishing our club as the sole representative from New Zealand. An impressive achievement considering the clubs recent entry into the competition just a year prior.

With the outstanding results from the Spaceport America Cup came increased interest with local outreach, culminating in a partnership with industry to execute the largest 'Hot Rockets' outreach program in our club's history. Over sixty youth between the ages of 7-17 built their own 'Hot rocket' in a single day, as just one of the outreach events run throughout the year.

As another part of our outreach program this year, over twenty students from a range of years and disciplines were given the opportunity to attend the New Zealand Aerospace Summit run annually in Christchurch. It gave our students a chance to showcase an extensive range of projects from the Bluestone and Redstone flight computers, to racing drones and some remote-controlled aircraft built by club members. But of course, Kāhu, our Spaceport America Cup rocket tock centre stage.

With 2023 came another great year of our long-standing programmes, most notably the Level 1 High powered rocketry program where more than twenty groups of four built scale patriot rockets and launched them at our Level 1 launch day.

Looking ahead to 2024, UC Aerospace is set for more ambitious goals than ever including the redesign of a Spaceshot vehicle, aimed at reaching the Kármán line and we will continue to represent UC, and New Zealand on the global stage at the 2024 Spaceport America Cup plus with many new partnerships such as with Children's University outreach remains a priority.


*UC Motorsport*

## UC Motorsport

UCM was founded in 2013, and over that time, the team have made nine Formula SAE cars and one land-speed vehicle. Over these ten years, UCM continuously generated successes with 2023 marking their most successful year.

As we celebrate our team's achievements, we also take pride in our role as a club for our team members moving on to pursue bigger and better opportunities after graduating. Some have joined the ranks of the Toyota Racing Series (TRS), showcasing their skills on an international stage, while others have found themselves contributing to the success of renowned teams such as Haas F1 Team. Their achievements are a testament to the foundation we have provided during their time at UCM, and we are proud to have played a role in their development.

As we move forward into 2024, we welcome the next generation of students coming through to take their place. We are busy analysing our performance at the competition and beginning to plan for the year ahead.

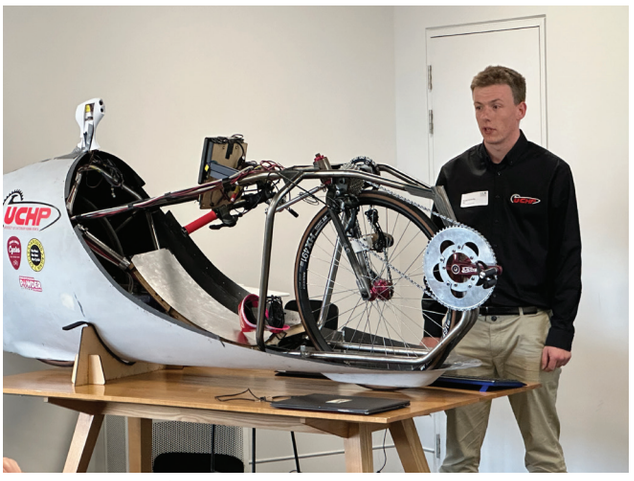
## UC Human Powered

The University of Canterbury Human Power club has made it through two years and ran its first FYP's as part of Project 100 in 2023.

The club membership grew to 36 members with expected future growth as there are now active projects which new students can see and directly engage in. The projects of the club are allowing newer students to upskill themselves and apply practical skills.

"Project 100" is UCHP's ongoing project to design, build and test streamlined recumbent bikes to beat the current New Zealand land speed record for an HPV (Human Powered Vehicle) and raise it to the open road speed limit of 100 kmph. Along the journey to this engineering achievement, we are seeking to raise public awareness of these vehicles and the possible performance of human power and how they are an alternative form of sustainable personal transportation. Which the club has opportunity to connect with other colleges of the University for wider engagement and impact.

*UC Aerospace Club*




*UC Human Powered*

*2nd year "Welcome to Mechatronics" event*

*UC BioMed*

*UC Sustainable Design Society (SUSD)*

Nine students where generously supported by the department, Bob Knight, and Aarn Tate to carry out work on the project as their final year project. The team took the idea of a land speed racing bike, researched what other teams are doing around the world and ideated what would be ideal for our context, and validating this with a Proof-of-Concept bike which the team tested out. The learnings from this were applied to the prototype design and a bike manufactured and named "Maroro" meaning flying fish. Initial testing has shown promising performance and is planned to be operationally tested in the new year before record attempts will be made.

## UC Mechatronics

In 2023 The University of Canterbury Mechatronics Society had a year of rejuvenation. A strong new executive team brought forward a fresh face for the club which was reflected in event and program output.

Small events included social barbecues which succeeded in bringing together the mechatronics cohort, weekly social study sessions, and a fourth year electives information session in which incoming fourth years for 2024 heard perspectives from 2023 graduates to guide them on elective choices.

We also established some key larger events which will be our defining outputs as a club moving forward. This included our UC FunKit drive, a sustainability program which oversaw the handover of 30+ ENCE260 circuit boards between year groups. It also included our two Industry Nights run in partnership with UC IEEE and UC BioMed, during which we hosted twelve companies, big and small, and sold out 200+ seats. As a result of this substantial revival, membership rose 25% to 260 members over the course of the year. This would not have been possible without the generous sponsorship of the UC Mechanical Engineering and Electrical Engineering departments.

Heading into 2024, the club is in good standing. We look forward to expanding our industry partnerships, bettering our core events and introducing new events to our portfolio which will provide stimulating co-curricular opportunities for our members.

## UC BioMed

UC Biomed ended the year with 81 members. In April we hosted a BBQ outside Herea-Roa as a networking event mostly for engineering students to meet and discuss biomedical engineering opportunities.

*Heart Hackathon* is UC Biomed's flagship event. *Heart Hackathon* is an annual international design competition which runs from February till November where teams from universities design, prototype and manufacture a total artificial heart. Throughout 2023 UC BioMed competed in the competition successfully meeting all deadlines and developed a prototype. In 2023 we had a team of 6 students working on different aspects of the design.

In collaboration with IEEE and UC TronSoc we hosted two successful industry Q&A evenings with several people coming from many different engineering companies. From the biomedical engineering industry we had Taska, Enztec, MedSalv and Fisher & Paykel healthcare. In total around 60 students attended each industry event.

*ENABLE* is a global initiative providing children with 3D printed prosthetic hands. They also provide open sourced resources to allow volunteers to help print and assemble hands. In 2023 the club 3D printed 15 hands and hosted an event to assemble them.

## UC Sustainable Design Society (SUSD)

2023 marked the formation of the UC Sustainable Design Society (SUSD). SUSD evolved out of a desire for extracurricular development opportunities focused specifically on sustainability. The club was formed by a group of mechanical engineering students competing in the US Department of Energy Solar Decathlon, an international building science competition for students. By starting the club, we hope to provide a space to explore all facets of sustainability and to focus on New Zealand specific opportunities. Our mission is to support general sustainable design endeavours and product development through education, collaboration, and outreach. The goal is to use the technical and analytical skills students develop at university to find creative solutions that can contribute to sustainable practices. At SUSD, we envision a future where sustainability is integrated into every design decision. Our club is driven by a collective passion to help build a better future.

Guided by the United Nation's Sustainable Development Goals (SDGs), SUSD has been a contributor to the new sustainability strategy for UC and its Graduates. The growing SUSD community fosters a space where members can explore innovative ideas for positive global effects. Whether it's by developing waste reduction strategies, renewable energy technology, or low-carbon materials, SUSD projects aim to support the solutions that provide hope. Our ethos is one of curiosity and optimism that we have the knowledge and resources available to us to operate sustainably. Beyond design and research projects, SUSD extends its reach to other events both social and educational. Through initiatives including industry seminars, member BBQs, ecological activities, and collaborations with other environmental clubs, we hope to provide opportunities for our members to connect with other passionate people from the local community. By collaborating both within the UC community and with industry partners, we believe knowledge sharing can spark the transition toward a sustainable future.

# Publicity & Outreach


*TechWeek (WestCoast): leaders Assoc. Prof. Stefanie GutschmidtIttai Perchig, and Esther Blain (president of WIE).*

In 2023 the Publicity & Outreach team was chaired and led by A/Prof Stefanie Gutschmidt, with Owen Kelly leading all technical aspects and Greta Rapalaviciute managing and overseeing all administrative tasks. Furthermore, 3rd year student Lydia Burnett was the key team leader and communicator to form and manage people and teams for our outreach events in 2023 on and off campus. The entire outreach team included a total of 32 members of a broad diversity of skills, programmes, female/male, years of experience. The team served the department, faculty and university in many regular events as well as new initiatives and one-offs.

Throughout the year we received fully-booked sessions and attracted large crowds of visitors. Whether on UC-Central-led events, such as UC Welcome Day, UC Discovery Day, and UC Open Day or the departments' own initiatives such as KidsFest2023 or hosting school groups, the expression of interest and number of participants were always more than we could hold sessions for. For example, on UC Welcome Day, Mech/Tron had two sessions for welcoming new 1st-year students, which attracted 459 and 209 students. On UC Open Day, Mech/Tron offered three sessions totalling 577 prospective students and touring nearly 300 students by 16 tour guides through our labs between 9 and 5 pm. On many of these outreach events the department strongly collaborated with the professional clubs (TronSoc, UCM, UCA, UCHP). Without these, our outreach efforts would not be nearly as effective and successful, and we have enjoyed, valued and keep appreciating this partnership for also years to come.

Smaller, no lesser successful, events were organized and driven by selected members of the outreach team, as follows:

**WIE Camp (Women in Engineering, 60 year 12 girls with interest in engineering hosted at UC from across NZ):** leaders Daniel Morris (PG) for Mechatronics, Dr Angus McGregor for Mechanical; Jordan Hill was the Lead Residential Assistant for the camp representing Mechanical Engineering and Lydia Burnett was an RA representing Mechatronics. The Mechanical Workshop focused on making Len Lye "alive" sculptures that worked using harmonics and vibrations. The Mechatronics Workshop focused on playing piano with an artificial hand or fingers. Students were very impressed with these workshops and scored one of these as their favourite.

**KidsFest2023 (2-day event, 4 sessions, 109 participants):** leaders Grace Windley (4th yr Tron) and Josh Peacocke (3rd yr Tron); for this event we have "employed" (Westfield Vouchers & Recommendation Letter) 6 highschool students from Rolleston Highschool and Middleton Grange, which assisted the leaders with activities such as e.g. the shake towers. One of these girls (Molly) returned for the WiE Camp after having enjoyed the experience being part of our team.

**Childrens Uni (28 & 29 June, 4x35 children, 40 min activities, age 7-12):** leaders Catie Mason and Danielle Gordon; 4 sessions of earthquake towers and wind tunnel.

**SouthMACH biannual industry Expo (24 & 25 May):** students who manned the stand: Grayson Spittle, William Thorpe, Max Sigley, Ethan Neal, Penelope Keeling, Ittai Perchig, Hasidu Wanniachchi, Yeni Choi. Staff: Owen Kelly, Malcolm Taylor, Don Clucas, Digby Symons, Stefanie Gutschmidt

SouthMACH is the South Island's premier technology trade show celebrating the heartland of NZ Manufacturing. This biennial event allowed coming face-to-face with the industry experts behind the key innovations entering the New Zealand community and showcasing our innovative projects and expertise. Our stand displayed the importance of education and research as an impacting driver for future innovations. In particular, we demonstrated cutting-edge research results of mixed-reality technology for future welding processes.


*SouthMACH: Yeni Choi with delegates*

# 150th Anniversary of UC – Alumni Weekend

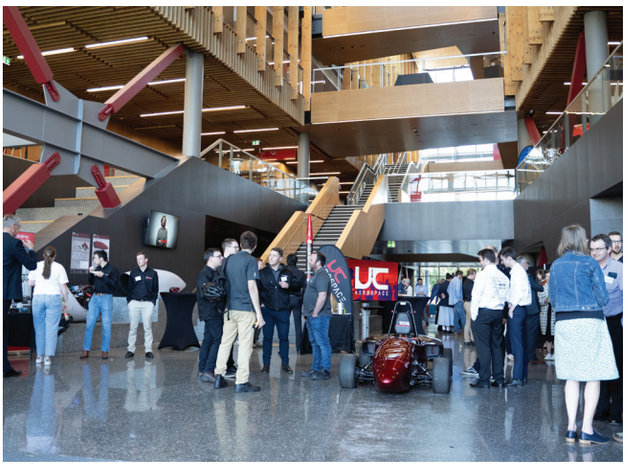

**150th Anniversary of University of Canterbury – Alumni Weekend:** leaders Greta Rapalaviciute, Ben Clark, Lydia Burnett, Josh Earnshaw, Grace Windley; with partnership and support from UCM, UCHP, and UCA.

At the alumni weekend on the occasion of the university's 150th anniversary, 27 October 2023, Mechanical Engineering welcomed 72 alumni and friends to an engaging program. In the inspiring space of the Ernest Rutherford Foyer we presented and displayed the department's achievements of 2023, celebrating our people and relationships – current and past students and staff, as well as partnerships of research collaborations and industry partners. After a warm welcome from the head of the department and some historic reflections on the department's journey, the focus of the achievements was on students' achievements through professional clubs and BE (Hons) Industry projects. While selected industry projects were put on display in the foyer, three of the professional clubs – UC Motors, UC Aerospace and UC Human Powered – delivered inspirational and engaging talks as well as displaying their "toys" to our guests – from race and landspeed-record cars, to rockets, to a record-attempting push-bike. UC Motorsport even pre-unveiled their new 2023 race car which soon would be shipped over to Australia for competing in the Formula Student 2023 event.

The atmosphere of this event among current students, staff and invited guests could not have been more energetic and inviting to also make plans for the future. Plans for new research and industry projects, engagement and encouragement of people supporting the ambitious goals of our professional clubs, as well as inspiring conversations with Alumni


about future opportunities for the department to impact society with solutions and the next generation of engineers.

In reflection, we are very thankful for the enriching community that we find ourselves in, within which our ideas, efforts and performance strive and find meaning. We would like to express our gratitude toward our guests on the day, as well as any party (individual or business) who has supported us past, present and future. We are thankful!

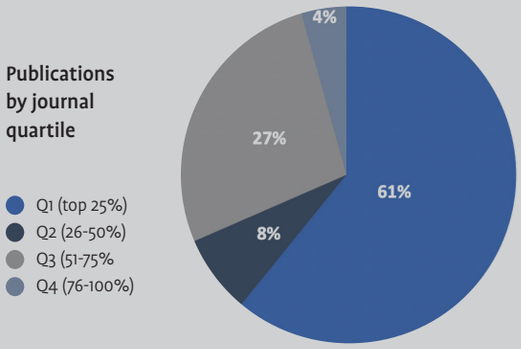



# Research

# Publications

In 2023, the Mechanical Engineering Department demonstrated its dedication to scholarly excellence by publishing 177 journal articles, 137 of which are indexed in the Scopus database. The department's strong performance in publication of its research findings is a testament to its commitment to advancing various fields through cutting-edge research, placing us second in the Faculty of Engineering for the number of high-quality peer-reviewed publications.

**Publications by journal quartile**




# Successful Research Grant Applications

For 2023, the department's external research income totalled over $1.3M in external contracts, with almost 80% of this funding originating from the Ministry of Business, Innovation & Employment. Our expertise and track record in delivering biomedical and aerospace engineering attracted over 70% of the above funding in 2023. This is a strong reflection on the capabilities and investment made by the department in these two globally important areas of research.

### Soul Machines – Digital Twins for the management of chronic metabolic disease

Type 2 diabetes (T2D) and cardiovascular disease (CVD) are managed primarily at home by the patient and whānau. Many patients struggle to understand their condition and how they should manage it, and are thus very often non-compliant with doctor recommended treatment. This is especially true of lifestyle changes to reverse early T2D. Intensive personal coaching or text-based motivation can be very effective, but are too costly for widespread use. The most promising way to address this growing and economically unsustainable problem is with digital technology. This project creates a platform of interconnected digital tools, starting with a culturally appropriate 'digital health navigator' fronted by Soul Machines' Digital DNA Studio, to coach patients in understanding their condition.

It builds on complementary physiological modelling projects at UoA and UoC to create a 'Digital Twin' specific to each patient. The Digital Twin will be informed by wearable sensor measurements of key health biomarkers and patient/navigator conversations about lifestyle. A new AI platform will analyse patient data and outputs from the Digital Twin, to help with rapidly adapting the patient's management plan. Partnering with Māori to shape the implementation of our technology will create a framework for culturally appropriate AI, and a platform applicable to a wide range of groups that experience unique challenges when engaging with the health care system.

### Tere Tīpako Tio: Rapid Extensive Antarctic Ice Sampling Aotearoa

Mechanical Engineering is collaborating with the Department of Geology at the University of Otago to develop new designs for rapid ice-coring technology for use in Antarctica. There is an urgent need of representative suites of ice samples to improve representation of ice physical properties (e.g. elastic and viscous properties and anisotropy) in ice sheet models. Such models are critical to predictions of the rate of sea-level rise that will result from the increased flux of ice from the land into the sea in Antarctica and Greenland. The extensive ice sampling needed, from many more locations and depths, has never been attempted, primarily because it is not feasible using conventional drilling practices, which require weeks to collect samples from single locations.

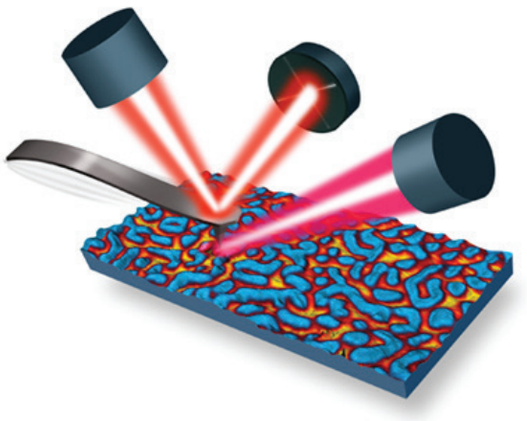
In the first two years of the project, the work undertaken by the Otago team has shown that they can drill holes rapidly with high pressure hot water, to diameters greater than 120mm so that ice coring devices can then be deployed in the hole. Two final-year Mechanical Engineering student teams worked on different designs of the ice core sampling hardware in 2023. One of these students, Jessica Macfarquhar, travelled to Antarctica in February with Otago collaborators including Professor David Prior and Hamish Bowman, to undertake field testing of the device developed during her Final Year Project. Jessica will begin a Master of Engineering degree in March, to further develop the core-sampling technology, based upon her recent field experience.

*Total pressure contours at nasal cavity cross-sections 15, 30, 45, and 60 mm (left to right) from cannula with NHF at 30 L/min.*

### Computational Fluid Dynamics of Upper Airway during Optiflow Duet Asymmetric Interface Nasal High Flow Therapy

Fisher & Paykel Healthcare has been a leader in providing breathing support solutions for patients with upper respiratory conditions. The Optiflow™ nasal high flow (NHF) therapy is used as a first-line treatment across the care continuum, may reduce patient escalation resulting in better clinical outcomes. Fisher & Paykel Healthcare is interested in understanding the upper airway flow characteristics when the novel Optiflow+ Duet asymmetric NHF cannula interface is used to demonstrate how it maintains deadspace clearance while generating higher positive airway pressure.

Master's student Zane Goggin under Dr Natalia Kabaliuk's supervision are modelling the flow through the upper airways during Optiflow+ Duet asymmetric interface NHF therapy for a range of NHF parameters to understand the flow sensitivity to the NHF operation parameters and to investigate the deadspace clearance with the use of asymmetric nasal cannula interface. The early findings were presented at the European Respiratory Society Congress in September 2023 in Mailan, Italy.

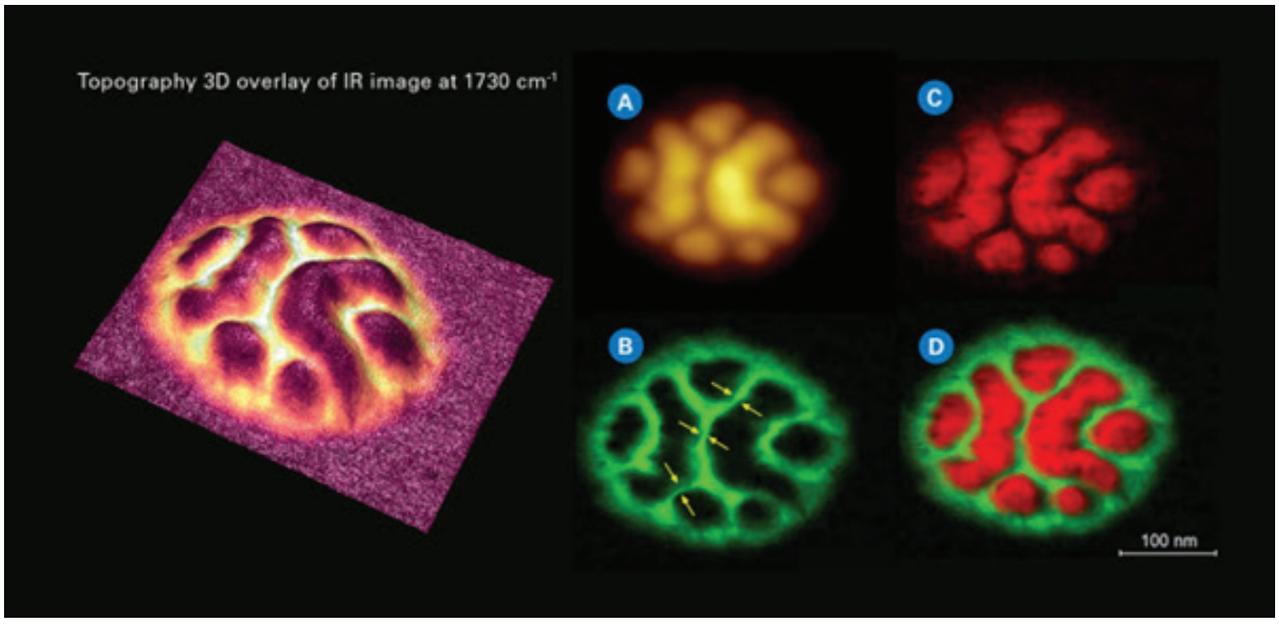


*Mapping of phase distribution of a polymer blend based on chemical analysis by NanoIR.*

*The Bruker Dimension IconIR system at UC – the first installation of its kind in Australasia.*

### A new state-of-the art microscope for materials research at UC

The Mechanical Engineering department was recently awarded CAPEX funding (led by A/Prof. Mark Staiger) for a new atomic force microscopy (AFM) platform that greatly enhances the materials research capability at UC. The Bruker Dimension IconIR system combines nanoscale infrared (IR) spectroscopy and scanning probe microscopy (SPM). The AFM-IR is a photothermal spectroscopy technique measuring the interaction of a material to the applied tuneable IR source. This allows spatial chemical mapping with a resolution of 10 nm and monolayer sensitivity for thin films and biological structures. The NanoIR system is the first of its kind in the Southern Hemisphere at the time of writing. The system is also equipped with first-of-its-kind nanoscale-dynamic mechanical analysis (nDMA). This allow characterisation of heterogeneous viscoelastic materials such as polymer composites, co-polymer blends and layered polymers that can be interrogated at the nanoscale, aiding our understanding of macroscopic properties of viscoelastic materials. Viscoelastic properties can be measured quantitatively on the nanoscale and compared with bulk DMA. The temperature and frequency dependencies can be assessed using the heated tip and/or stage (25-250C) and wide spectrum actuator (0.1Hz-20kHz) in a gas shielded atmosphere. The AFM platform is also equipped with PeakForce quantitative nano mechanical mapping (PeakForce QNM) enables high resolution mapping of nanomechanical properties (such as modulus, adhesion, dissipation, and deformation) over a wide operating range of samples, from soft materials (~1 kPa) to hard metals (100 GPa). Contact resonance can be used to measure the sample dissipation and stiffness by analysing the cantilever resonance while it is in contact with the sample surface. Contact resonance can be used to measure materials at very high stiffness (350GPa). Kelvin Probe Force Microscopy (KPFM) enables high-resolution measurement of surface potential in conjunction with topography mapping. Additional electrical properties can be characterised using current sensing instrumentation from ultra-low, femto-amps range for poor conducting materials using Tunnelling-AFM (TUNA) to micro-amp range with TUNA or conventional Conductive-AFM (C-AFM). A fluid tip holder allow imaging in a fluid environment which can be useful for observation of biological specimens under native conditions, minimising surface forces for delicate samples, and allowing the observation of samples undergoing chemical reactions. A large sample capability on the main imaging chuck allows samples up to 150mm diameter. The new AFM platform at UC represents a powerful capability that is unique within Australasia.



# Stories of 2023

## Rolling resistance of e-Scooter tyres

**(George Stilwell, Associated Professor Shayne Gooch, and Martial Lafitte)**

With the huge uptake in the use of e-scooters worldwide, George Stilwell, Shayne Gooch, and Martial Lafitte developed an e-scooter tyre testing trailer to enable tyre rolling resistance data to be captured. Using a load cell near the trailer coupling, towing forces were measured. The trailer has been designed such that tyres can be tested at a variety of test velocities, and a range of different surfaces. Initial testing with 9 different e-scooter tyres enabled the co-efficient of rolling resistance to be determined and compared, with the results being published in the Design2024 conference proceedings. The results were interesting of the comparison were interesting as rolling resistance varied between apparently similar tyres. This variation highlighted that simple assumptions based on tyre dimensions and construction methods are not necessarily a good predictor of tyre energy losses due to rolling resistance. It is hoped that the results of this work will help to provide consumers and designers useful information to make informed choices regarding tyre selection on these devices. The selection of tyres with lower rolling resistance will help to reduce the energy usage and environmental impacts of these devices.

## Protecting Aotearoa from aerial invaders in a changing climate

**(Masters student Joseph Lynch, Professor Mark Jermy)**

Recently, a study of the aerodynamics of pine tree seeds by Masters student Joseph Lynch concluded successfully. This was funded by Scion as part of a campaign to better control the spread of wild pines. Following on from this work, Mechanical Engineering is now part of a $10 million MBIE Endeavour Research Programme, led by Scion, to understand the wind-borne transport of potentially harmful insect species and plant disease spores to NZ. Work in Mechanical Engineering, to build a chamber for studying the flight of moths, will be led by Mark Jermy. The public statement for the programme is:

In New Zealand, and globally, there is a gap in biosecurity defences. This gap allows aerial invaders-invasive pests (insects and pathogens) to reach New Zealand via the wind-assisted pathway; they can spread within New Zealand via this pathway, irrespective of their arrival mode. There are no effective tools to manage this pathway of pest movement, leaving a hole in our biosecurity net. This hole will widen as climate change brings extreme weather events able to transport aerial invaders to our shores, and as the habitat ranges of these invaders expand – both in their source regions and in New Zealand.

It is time to tighten our biosecurity net and close the aerial invader hole.

Our diverse science team will develop a novel, integrated Aerobiological Surveillance and Prediction System (ASaP) to close the aerial invader hole in our biosecurity net. ASaP integrates internationally new science on:

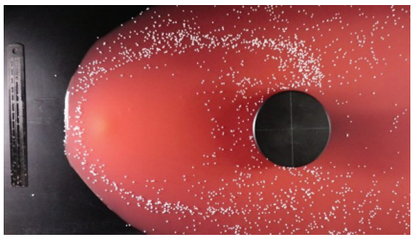
- long-distance atmospheric dispersion modelling
- atmospheric boundary-layer dynamics
- rainfall washout/survival by flying insects.

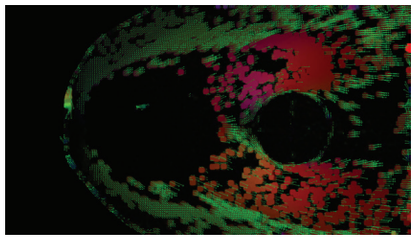
We also extend existing knowledge on pathogen atmospheric-transit survival, and include innovative aerial invader surveillance by our Māori Partners Taranaki Mounga on the Taranaki coast.

## Indirect measurement of lava rheology

**(Professor Mathieu Sellier, Dr James Hewett, PhD students Dale Cusack, David Muchiri)**

Mathieu Sellier and his team have developed and implemented new tools which allow the remote identification of the rheological behaviour of complex fluids using information about the free surface obtained from aerial imaging. The targeted application for this project is lava flows since the hot and corrosive nature of lava is incompatible with standard rheometers and there exists many aerial footage of lava flows. The identification is achieved by finding the optimal rheological parameters which minimize the difference between simulated data using bespoke models and observations from either experiments using a lava analogue or field measurements.





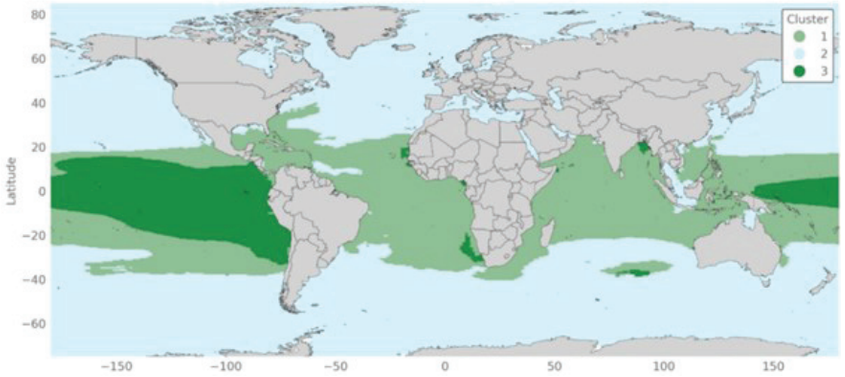
*View from above of the flow of PEG600 down an inclined plane and around an obstruction. Buoyant makers are visible and enable the reconstruction of the free surface velocity field.*

The team used particle tracking velocimetry technique to extract the free surface velocity of gravity-driven flows in the lab or in the field. They have also developed new lower-order flow models based on the Shallow Water Approximation applicable to arbitrary rheology which are computationally efficient but able to accurately capture the flow dynamics and the free surface features. The methodology was successfully tested in the lab and the team has plans demonstrate it with field data next.

This project was funded by the Marsden grant "Indirect measurement of lava rheology"

## Denkenberger now second most published author in the world in the existential risk field

**(Associate Professor David Denkenberger)**




*Seaweed growth rates for nuclear war causing burning of cites and the smoke reducing sunlight and temperatures. Colours indicate different clusters (dark green is the best growth, light green is moderate, light blue indicates barely to no growth).*

David Denkenberger edged out Oxford professor Nick Bostrom, widely regarded as the founder of the existential risk field, to become the second most prolific author in the world in the global catastrophic/existential risk field. The algorithm for locating the papers was a combination of machine learning and human evaluation. Denkenberger has 24 papers in this field, including ones on risks from artificial intelligence, including classification, military, risk communication, and cost effectiveness of mitigation. Also, Denkenberger cofounded the subfield of foods resilient to abrupt sunlight reduction scenarios including large asteroid/comet, volcano, or nuclear war catastrophes, and publications include extracting protein from leaves, scaling up low-tech greenhouses, seaweed, and turning natural gas into protein, wood into sugar, hydrogen into protein, petroleum into fat, electricity into vinegar, and carbon dioxide into glycerol (glycerine). Further publications explored nutrition of these resilient foods, and cost effectiveness of them saving lives. Denkenberger has also published on resilience to catastrophes that could disrupt electricity, such as extreme solar storm, cyber attack, detonation of nuclear weapons at a high-altitude causing electromagnetic pulses, and extreme pandemic causing people to be unwilling or unable to work in critical industries. Part of that is ensuring food, but also water, heating, and communications. Though the focus of this work is to reduce the chance of collapse of civilization, from which we may not recover, affecting many future generations, there are many times benefits to sustainability, reduced greenhouse gas emissions, and reduced famine now.

*UC undergraduate Simon Charman collected local seaweed and built this wood fire drying apparatus.*

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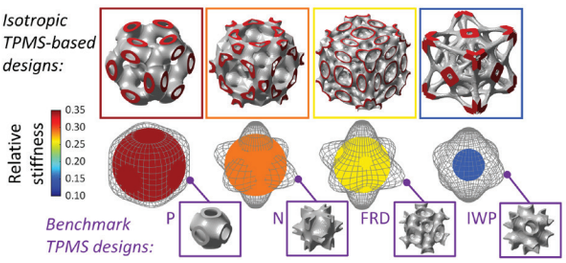
## Unlocking Isotropic Strength: Revolutionising Cellular Structures with Triply Periodic Minimal Surfaces

**(Dr Stephen Daynes)**

In the realm of load bearing and energy absorbing applications, such as protective head gear and packaging, achieving isotropy – the ability to uniformly respond to external forces from all directions – is paramount. Triply Periodic Minimal Surface (TPMS) cellular structures have emerged as frontrunners in this domain, boasting exceptional performance, customisable properties, and an open-cell architecture. However, traditional TPMS designs have struggled with stiffness anisotropy, limiting their potential.




In a groundbreaking study, novel design strategies have been unveiled to engineer isotropic TPMS-based cellular structures, tapping into a vast design space of relative density and stiffness.

Four distinct families of cells, each based on a different TPMS unit cell, are optimised using finite element analysis and 3D printed. Experimental compressive tests across multiple crystal orientations and print orientations validate the designs' isotropic nature, showcasing impressive stiffness, strength, and energy absorption properties.

This study not only pushes the boundaries of structural engineering but also offers a promising avenue for developing isotropic cellular materials with unparalleled performance in diverse applications.

Findings have been published in Additive Manufacturing.

## Extrusion-based additive manufacturing, a sustainable upcycling waste management route for semicrystalline thermoplastics

**(PhD candidate Mohammad Sagor Hosen and Associate Professor Mark Staiger)**

Extrusion-based additive manufacturing (EBAM) is a cutting-edge upcycling technology that provides a fresh avenue for sustainable waste management of semicrystalline thermoplastics and diversifies the applications of recycled thermoplastics. Despite having tremendous potential, EBAM application to semicrystalline thermoplastics encounters substantial hurdles rooted in the intricate microstructural transformations during processing. The dynamic transformations in microstructure lead to warpage through differential shrinkage and consequential decline in the mechanical and thermal stability of the final product. Acknowledging the pivotal role of microstructure in determining properties, especially post-thermomechanical processes such as EBAM, PhD candidate Mohammad Sagor Hosen and Associate Professor Mark Staiger embark on a comprehensive investigation on microstructural evolution of a semicrystalline thermoplastic following each iteration of EBAM. The study discerns alterations in crystallisation kinetics, crystal dimensionality, crystallite size, overall crystallinity and microstructural contents (rigid and mobile amorphous components). The microstructural alteration has established as an underlying factor and significant contributor to the observed differential shrinkage (warpage) and diminished tensile properties and thermal stability in the final part following each processing cycle. Sagor is optimistic that the research findings delving into the microstructural insights of semicrystalline thermoplastics will assist in yielding printed parts endowed with tailored mechanical and thermal properties with minimum warpage. The resultant knowledge will facilitate the development of the emerging technology EBAM as a sustainable upcycling tool for semicrystalline thermoplastics, marking a stride towards optimised EBAM practices.

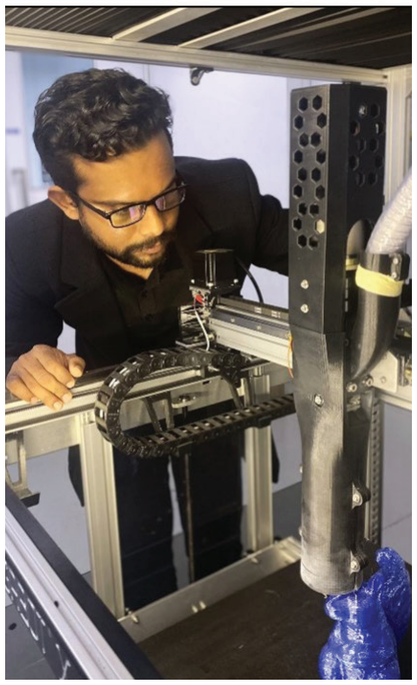


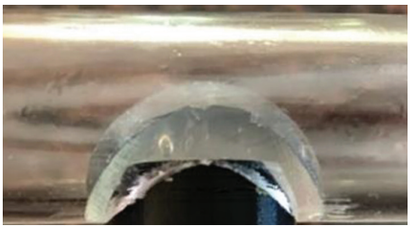
*Figure: Extrusion-based additive manufacturing of recycled semicrystalline thermoplastic (i.e. polyethylene terephthalate).*

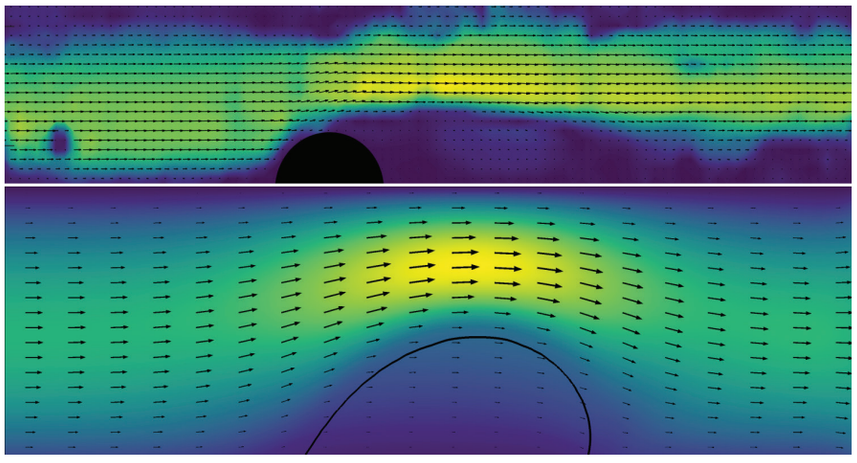
## Characterising the biomechanical properties of blood clots

**(Dr James Hewett)**

This research will advance our understanding of how blood clots form in our blood vessels and how they grow over time. Deep Vein Thrombosis (DVT), the formation of a blood clot within a deep vein (commonly in the legs), is a potential problem for anyone who remains still for extended periods of time; for example on a long-haul flight or an extended hospital visit. This blood disorder is potentially life-threatening and you may not have any noticeable symptoms. Blood clotting is an important part of the normal wound healing process but can essentially overcompensate for the problems caused by the wound and result in complications. Blood clots, and particularly DVT, are more prevalent within the older population and enforces a significant economic burden on our healthcare system as well as degrading quality of life. We propose to numerically simulate the formation and growth of thrombi in blood vessels and compare and validate our results with both inhouse experiments and with those performed by our collaborators who have world-class facilities for optical imaging of living organisms. In our proposed project we will utilise this experimental data in conjunction with our own numerical simulations to quantify the growth rate and mechanical properties of thrombi. Thrombi may become lethal when they dislodge from the blood vessel wall and flow through the blood stream towards lungs, causing a blockage known as pulmonary embolism. Understanding the mechanical properties and response of thrombi would enable a prediction for clinicians on whether or not a thrombus would embolise. The novelty and primary contribution of this work is the creation and robust validation of a computational model for predicting the physical dynamics of thrombi, in order to facilitate the development of effective treatments for venous thrombosis.

*Prototype testing of blood clot analogues in laboratory conditions (top) with flow visualisation of the velocity field using particle image velocimetry (middle), and a close-up of a deformed clot from a numerical simulation (bottom). Flow is from left to right, and the quickest flow is shown in yellow (narrowest region above the clot).*





# Achievements

# Faculty of Engineering Annual Staff Awards


*Natalia Kabaliuk and Mark Staiger received the Emerging Teacher Award and Established Researcher Award (respectively) at the Faculty Award ceremony.*

# UC Motorsports winning Formula Student competition in December 2023

With the support of the department, many sponsors and friends UCM achieved the monumental feat of winning the 2023 Formula SAE Australasia competition.

Throughout the competition, UCM competed in a range of static and dynamic events that tested every aspect of the team and car, both on and off the track. The challenges ranged from design evaluations and business presentations to the intense dynamic events of autocross and endurance races.

In the end, team achieved the following results:

- 7th Business Presentation
- 6th Cost and Manufacturing
- 3rd Design
- 5th Acceleration
- 3rd Skidpad
- 5th Autocross
- 2nd Efficiency
- 3rd Endurance
- 1ST OVERALL

These results also increased UCM in the Formula Student Electric – World Ranking from 23rd to 4th in the world, our highest position to date.



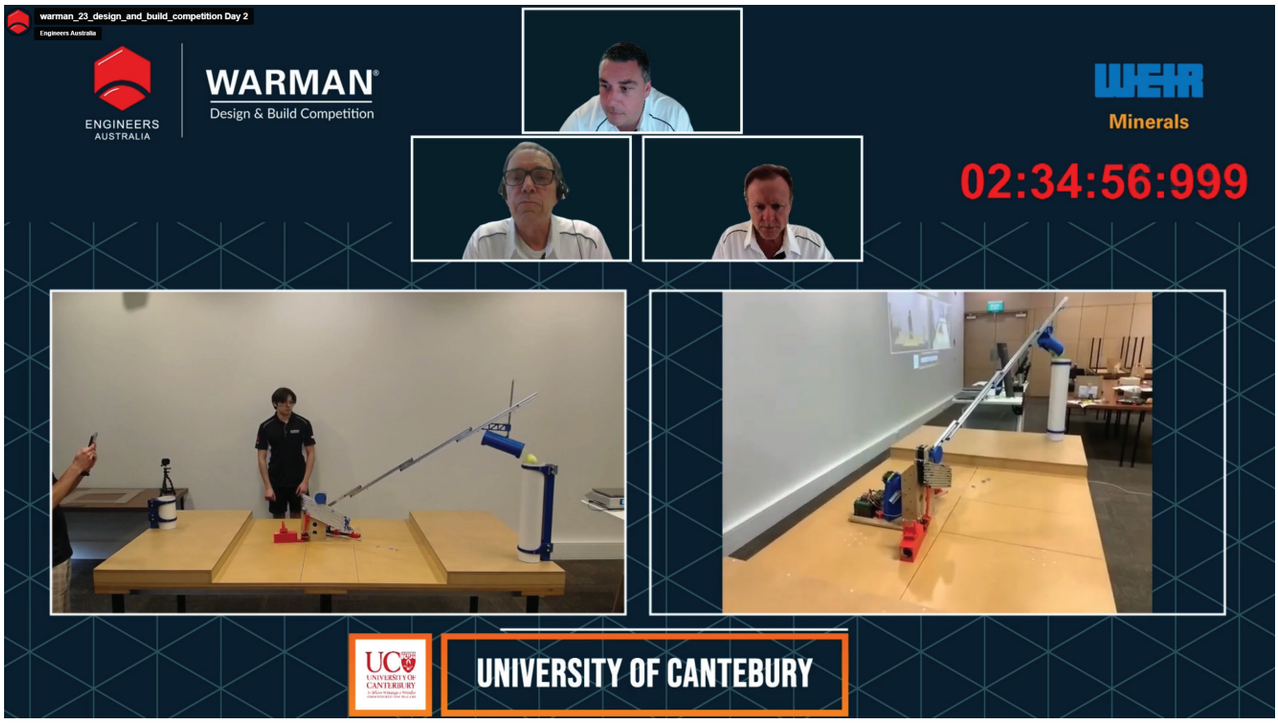
# Spaceport America Cup 2023

The 2023 UC Aerospace team WON the 30K COTS Category and placed 3rd overall at the 2023 Spaceport America Cup.

The Spaceport America Cup is the world's largest student rocket engineering competition and conference, attracting over 150 teams from 24 countries. The Spaceport America Cup is hosted at Spaceport America, the world's first commercial spaceport, in New Mexico USA, and the competition is run by the Experimental Sounding Rocket Association (ESRA). The competition continues to grow each year, with students designing and building solid, hybrid and liquid rockets to launch in 10,000 ft and 30,000 ft categories. This year, around 5,900 rocketeers will be competing.

# Best Student Paper Award in Engineering Acoustics

Under the guidance of Professor Dan Zhao, PhD student Lixian (Lowrence) Gou had the privilege of representing the Mechanical Engineering of the University of Canterbury at the Acoustics 2023 Conference (185th Meeting of the Acoustical Society of America and 2023 Meeting of the Australian Acoustical Society), held by the Acoustical Society of America and the Australian Acoustical Society in Sydney last December. Lowrence have been awarded with the Best Student Paper Award in Engineering Acoustics. His research topic: Effects of temperature difference and operating pressures on heat-driven acoustic characteristics and nonlinear behaviors in a looped tube traveling-wave thermoacoustic engine. In this work, the output heat-driven acoustic characteristics and dynamic thermal-fluid flow fields in a looped-tube traveling-wave thermoacoustic engine (TWTAE) are numerically investigated. Emphasis is placed on optimizing acoustic power output from the TWTAE by varying its operating pressure and temperature difference across the regenerator. For this, a time domain full-scale 3-D TWTAE model is developed, and then validated by comparing with those results obtained from the experimental data available in the literature. The present results indicate that the acoustic pressure oscillations and the acoustic power are increased with the increased operating pressure of the working gas. Furthermore, nonlinear acoustics and flow dynamics in the heat-driven acoustic and flow fields of the TWTAE such as vortex generation around the regenerator and Gedeon streaming are observed. In summary, the present 3-D model can be used as a design tool for predicting and optimizing looped tube TWTAE performances with detailed thermo-fluids dynamics and acoustics characteristics.

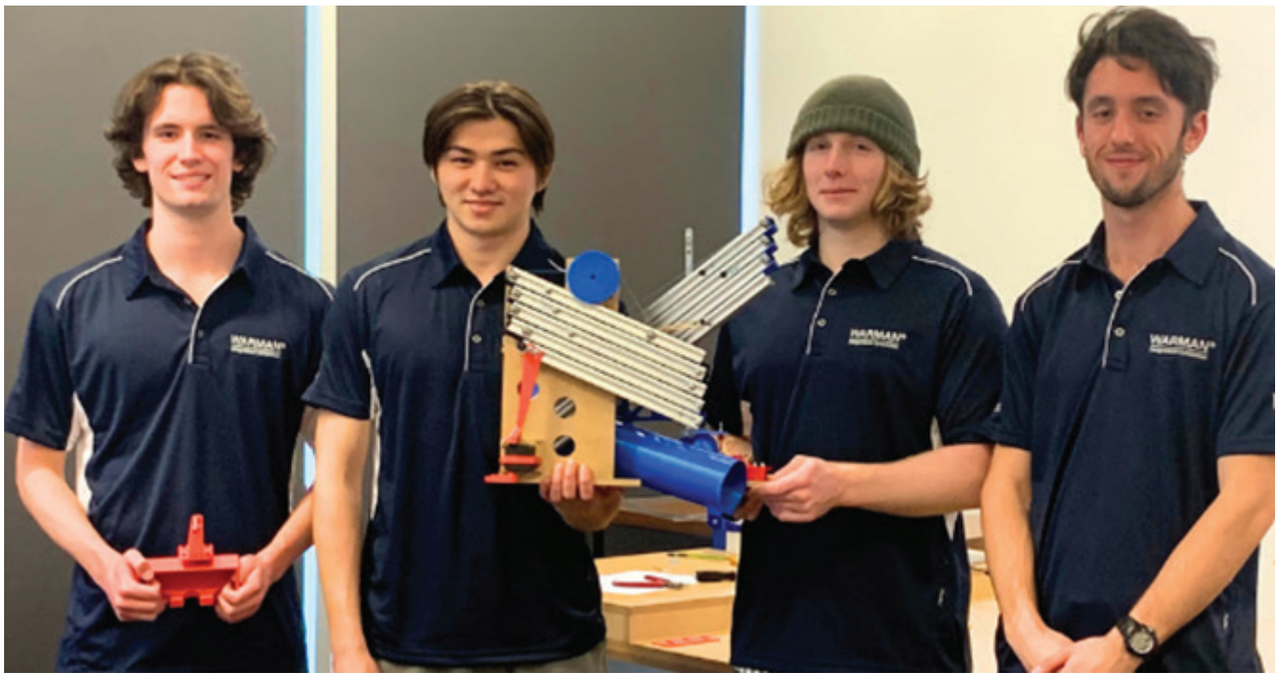



*Warman competition 2023.*

# 36th International Warman Design and Build Competition Winners

Each year, our second-year students compete for the honour of representing The University of Canterbury at this international competition. The design, build, and compete challenge is run as assignments for ENME201 (Design Communication) in Semester One and ENME221 (Design and Manufacture) in Semester Two. Locally, about 220 students from Mechanical Engineering and the School of Product Design compete in teams of four.

Internationally, about 2000 students from Australasian universities compete, which created 16 campus entries for the 2023 final. Canterbury regularly brings home a significant prize, and for 2023, our team that won the local competition, convincingly won first place at the final. This is an outstanding achievement, so the team deserves our congratulations.



*Harry Crump, Luka Phillips, Jared Shelling and Lachlan Mackie (C).*

**For more information, contact:**
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