

Mechanical Engineering

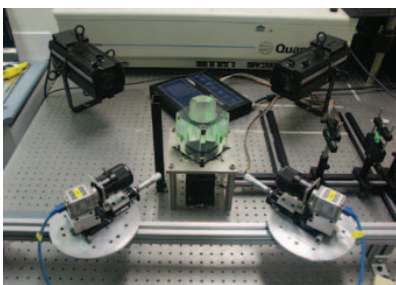


Alpine skier using the wind tunnel to improve skiing times before the 2006 Torino Winter Olympics in Italy.

Research expertise in Mechanical Engineering can vary from rocket motors to sub-sea pipeline engineering, from studying the effects of wind drag on Torino Olympic-hopefuls in the Wind Tunnel to blood flow velocity effects on white cell adhesions in the Synchrotron.

Mechanical Engineering prides itself on its research – its research staff, postgraduate students and research facilities.

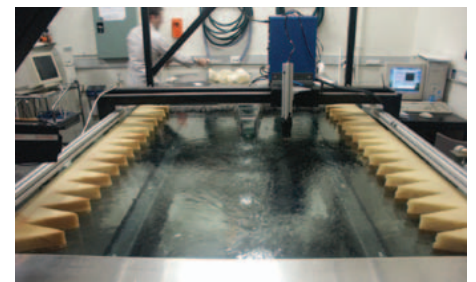
The Department's research is no longer confined to only the traditional fields of mechanical engineering; increasingly, engineering research and interdisciplinary research is happening in joint partnerships and/or collaborations with other engineering departments, departments of other faculties, other universities, industries and research organisations, nationally and internationally.



Bioreactor rig optical setup to perform PIV (Particle Image Velocimetry) analysis of flow in a bioreactor vessel to improve understanding of biological tissue cultivation.

Research strengths of the Department are exemplified in both basic and applied research. The Department's research areas consisting of the following are constantly challenged by a diverse range of theoretical hypotheses and real-world problems.

- **IRT (Institute of Railway Technology)** – conducts critical research into tracks, vehicles, materials, wheel-rail interactions, monitoring systems, and noise studies. In addition, it is a leader in railway systems, and provides a range of analytical and testing services and resources to rail industries, nationally and worldwide.
- **MTI (Maintenance Technology Institute)** – conducts research into and provides comprehensive high level contract R&D and engineering consultancies in areas of asset management and plant performance for heavy engineering industries, nationally and internationally.
- **Structural Mechanics, DSTO (Defence Science and Technology Organisation) Centre of Expertise** – *inter alia*, investigates structural mechanics and failures, fatigue of structures, fracture mechanics, and monitors *in situ* structural health.
- **FLAIR (Fluids Laboratory for Aeronautical and Industrial Fluid Dynamics)** – a world leader in experimental and computational fluid mechanics research, its research outcomes have wide impacts on industries such as automotive, aeronautical and bio-medical.



The water facility used to model screech noise from supersonic jet nozzles that will lead to quieter and safer operations of military and civilian aircraft worldwide.

- **LTRAC (Laboratory for Turbulence Research in Aerospace and Combustion)** – conducts research into turbulence, aerodynamics and flow controls, propulsion and combustion. It possesses extensive laboratory facilities for studies into diesel engine and fuel, hybrid rocket and combustion, and image processing.
- **RMRL (Robotics and Mechatronics Research Laboratory)** – typifies emerging interdisciplinary engineering research in the areas of design, intelligent products, control systems and processes. The Laboratory works with industries, other research centres/laboratories and universities.
- **Micro/Nano Physics Research Laboratory** – it is rising to the challenges of micro/nanoscience in the study of intermolecular and interfacial forces in the forms of micro/nano mechanical systems and micro/nanofluidics in the fields of medicine, biomaterials, and commercial applications.

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In addition to the above research strengths, attesting to the research strengths of the Department, Mechanical Engineering is also involved in –

- the CRC for Advanced Automotive Technologies;
- the CRC for Advanced Composite Structures;
- the CRC for Integrated Engineering Asset Management; and
- the CRC for Railway Technology.

The need for cross-disciplinary expertise in so many research areas is increasingly evident. The Monash University Biomedical Engineering Technology Alliance (MuBeta) brings together biomedical and engineering researchers and educators to work on examining research issues such as in renal circulation, cardiovascular regulation, bioreactors, artificial biological pumps, tissue engineering, stem cells and biophysical fluid mechanics. Advanced imaging techniques from synchrotron and photon microscopy to particle image velocimetry (PIV) have become indispensable tools in both MuBeta's research and for educating the next generation of biomedical scientists and bioengineers.

Fluid Mechanics

Vehicle and aircraft aerodynamics, energy transport and mixing at scales and speeds from those over supersonic aircraft to microscopic blood flows, are studied using a range of techniques, including digital laser diagnostic systems, wind and water tunnels, and a water table facility. Researchers are able to hone in on solutions to problems in manufacturing, building and construction, defence, mineral processing, biomedical engineering and aerospace. The Department has a particularly strong group in Computational Fluid Dynamics, which has established an international reputation for its work ranging from the most fundamental to the strategic and tactical.

Composite Structures

The ability to measure the onset of fatigue damage, stress states, damage tolerance and impact studies, has given Monash researchers a unique research capability, not found elsewhere in Australia or the world. Application of research outcomes has benefited aircraft structures, vessel fractures, and rail infrastructures.

Micro/Nanoscience

Engineering research activities in this field, utilising membrane and separation technologies have yielded results for biomicrofluidic applications for electro-spraying, electro-hydrodynamic mixing of electrolytes and dielectric liquids for drug delivery and encapsulation, biomaterials synthesis and more. In addition, it has given impetus to the modelling, design, fabrication and applications of microactuators and microsensors.

Postgraduate students in Mechanical Engineering choose from a wide array of research topics, varying from the traditional to esoteric, typically:

Engineering dynamics; hydraulic and pneumatic systems for powered control and logic; kinematics and mechanisms; robotics; manufacturing management and technology; experimental and computational structural (solids) mechanics; composite structures; bonded structures; smart materials; vibration analysis and control; acoustics and noise control; environmental fluid mechanics; transition and turbulence; computational and experimental fluid mechanics; free surface flows; computer modelling of complex industrial flows; direct simulation of turbulence; physics of



Loading of iron ore onto a long (approximately 3 km) BHP Iron Ore train.

Mechanical Engineering's research vision is aligned with the Faculty and University's guiding themes of **Engagement**, **Innovation** and **Internationalisation**. The Department recognises the value of the outstanding research capabilities of its staff and students and its research facilities.

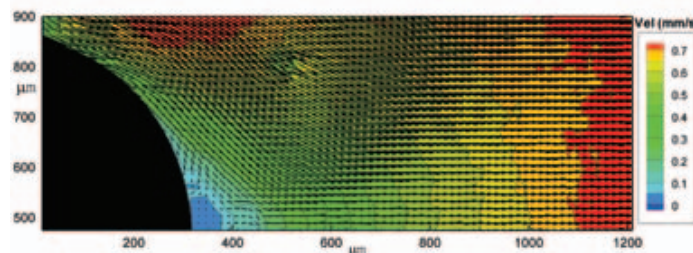
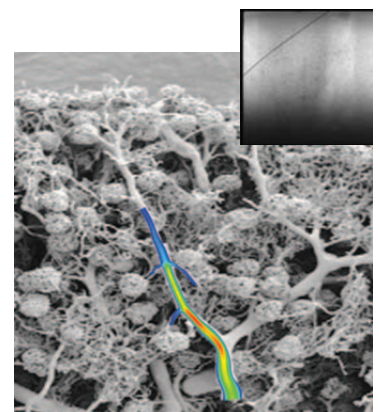


Image of a micro PIV field measuring effect of high fluid shearing on leukocyte adhesion.

swirling flows; fluid-structure interaction; aeroacoustics; flow stability; aeronautical fluid mechanics; development of numerical methods for flow modelling; wind effects on buildings and structures; hydrodynamics and water quality of bays and estuaries; mixing in swirling flows; scalar mixing; energy conversion; heat transfer and gas flow in non-circular ducts; boiling heat transfer; technology policy; automation; control and systems; machine condition monitoring; materials testing; composites and adhesives; pumping systems; manufacturing engineering including machining; automation and flexible manufacturing; industrial engineering, including manufacturing and resource planning; optimisation of manufacturing systems and quality improvement, renewable energy and energy conservation.

The Department, besides enhancing research in its traditional areas, is also embracing interdisciplinary research and collaborations. It is interacting actively with industry, research organisations and the government and responding responsibly and professionally to identified engineering needs and issues in the world.



A numerical simulation of blood flow in a portion of the kidney vasculature superimposed over a cast of an actual kidney.

(Inset) A medical synchrotron imaging of blood flow in a kidney (the line across the image is a 0.1 mm diameter wire for scale). Mechanical engineers are developing advanced imaging systems and enhancement algorithms to improve the details of synchrotron imaging.