DES News

Department of Engineering Science

May 2013 | **Alumni and Friends quarterly newsletter** | Number 18

Dear Alumni and Friends

2013 is well and truly underway around the Department. We have a great group of students in Part II beginning their time with us. There are 48 new students in the Engineering Science degree and 28 in the Biomedical Engineering degree. Entry was competitive, with further students being turned away due to limited capacity in the Department. We were also pleased to see 32 students graduate in a rather wet graduation ceremony on May 6th. They are going on to a range of interesting employment and further education opportunities in NZ and around the world.

The Tertiary Education Commission recently released the results of New Zealand's Performance Based Research Fund. This exercise compares and rates all the academic entities in the country using a metric that considers the quality of research outputs by staff, the international esteem the staff are held in, research grant funding, and postgraduate student completion numbers. DES received an overall score that ranked us as the top Engineering Department in New Zealand. Across all subjects, universities and departments Engineering Science ranked within the top 20 in NZ. Everyone associated with the Department should be very proud of this result. Our challenge now is to sustain and further develop that level of quality.

Associate Professor Rosalind Archer, Head of Department
des-hod@auckland.ac.nz

Autumn Graduation 2013, Congratulations to:

Bachelor of Engineering (Honours) including Conjoints with First Class Honours

Biomedical Engineering

Chun Meng Goh
Sue Mun Huang
Qi-Wern Lim
Simon Mekhail
Sarah Milsom (BA/BE Honours)
Ka-Shing Ng
Kejia Wang

Engineering Science

Vincent Bachtiar
Chrislyn Braganza
Zabin Farishta (BCom/BE Honours)
Oliver Hinder
Alan Lee
Michael MacDonald
Brad Raos (BE Honours/BSc)
Matthew Steel
Xiaoxiao Ye

Bachelor of Engineering (Honours) with Second Class Honours, First Division

Biomedical Engineering

Helen Liley

Engineering Science

Samuel Cheng
Matthew Crowder
Michael Hanks
Esther Lloyd
Nicholas Porter

Bachelor of Engineering (Honours) with Second Class Honours, Second Division

Biomedical Engineering

Natalie Diprose
Haiyao Huang
Hassan Raslan
Aaron Smith
Xin Yue Zhu

Engineering Science

Marie Campbell

Bachelor of Engineering in Engineering Science

Matthew Rouse

continued overleaf...

In this issue

David Ryan

David Ryan had a health scare back in February which resulted in him spending a period of time in hospital. The source of his illness remains undiagnosed, however his recovery is progressing well, and he is feeling very much better.

Because of his illness, David decided to officially retire from his position with the University but hopes to return on a part time basis when he has fully recovered. David can be contacted by email at d.ryan@auckland.ac.nz.

News in brief...

Nield book in 4th edition

The 4th edition of Convection in Porous Media by Don Nield and Adrian Bejan (Duke University) has been published by Springer. In its various editions, which have appeared at intervals of seven years, this book has been cited over 2400 times. It is both an introduction and a research reference on the subject (the latest edition has 778 pages and 4700 references).

Do you have news to share?

We would love to include news from alumni and former staff. If you have something you'd like to share, email des-newsletter@auckland.ac.nz

Bassy Tam, Doctor of Philosophy in Engineering Science

Thesis: Optimisation approaches for robust airline crew scheduling

Photo: Bassy and her son, Issac

The goal of the tour of duty problem in airline crew scheduling is to partition the flights of a schedule into a minimum cost set of tours of duty that crew members can operate. The pairings problem is traditionally solved separately for each crew rank, which can cause crew to split up after operating a flight. In case of disruptions, this effect contributes to the propagation of delay through the schedule. Unit crewing, i.e., keeping crew of different ranks together for as long as possible during a tour of duty, is a way to avoid this and to generate operationally robust solutions. Traditionally, this is done sequentially by solving the tour of duty problem for one crew rank first and when solving the pairing problem for the next crew rank add a penalty to the cost of the problem whenever a tour of duty differs from that of the first rank.

In her thesis, Bassy addresses the problem by solving the two tour of duty problems simultaneously and using multi-objective optimization methods that consider cost as well as "keeping crew together" as optimization objectives. Bassy first presents a multi-objective formulation for the sequential approach, which generalises the traditional way of solving the problem. Then she introduces the multi-objective simultaneous optimisation model. She solves the sequential model using standard techniques. For the simultaneous model Bassy develops and implements a new heuristic branching technique that favours unit crewed tours of duty. She compares this with a Dantzig-Wolfe decomposition approach. Numerical tests on Air New Zealand data show that the multi-objective approaches considerably increase the level of unit-crewing, without much increase in cost, even in the sequential approach. Moreover, the simultaneous approach is superior in terms of quality of the tour of duty solution, but computationally more expensive. The heuristic branching approach provides good quality solutions in reasonable time, as compared to the Dantzig-Wolfe method.

Luqman Bachtiar, Master of Engineering

Thesis: Multi-layer perceptron classification of unknown volatile chemicals from the firing rates of insect olfactory sensory neurons and its application to biosensor design

A biosensor that emulates a biological olfactory system can be produced to detect and recognise various odours and flavours. Such a device has a broad range of applications such as: determining the ripeness of fruit, detecting contraband or explosives and even for diagnosing illnesses in a patient.

In this thesis the olfactory sensory neuronal firing rate patterns of various insects such as the fruit fly and mosquito are studied. These patterns are used to train an artificial neural network to predict and distinguish different chemical classes of volatile odorants.

Luqman has returned to DES as a PhD candidate.

Kevin Cheong, Master of Engineering

Thesis: Design and development of a new knee prosthesis design

Osteoarthritis is a form of joint disease that affects all people and is not race or age specific, though it is more prevalent in the elderly. As the amount of people diagnosed with osteoarthritis continues to rise, there is an increase in dependency on joint replacement. The interest of this research project is the design and development of a novel knee prosthesis.

This thesis describes the process involved in the development of the implant. It is based on a number of concepts and was designed with the CAD software SolidWorks. The model was then exported to the Abaqus software, where it was analysed numerically using the finite element method. Preliminary results for the prosthesis were encouraging: the prosthesis successfully removed stress across the tibiofemoral joint, while not introducing any negative secondary effects. The prosthesis itself managed to withstand the compressive forces involved. After the initial analysis, further improvements to the initial design were identified and implemented. These included recommendations made on the shape of component bodies, locations of prosthesis holes, as well as the amount and positioning of pins.

A cadaver knee specimen was acquired and CT scanned at Ascot Hospital in Auckland. A prosthesis specific to the cadaver was designed in SolidWorks and subsequently manufactured using metal casting. Experimental testing on the cadaver and the prosthesis prototype was carried out using an Instron machine at the Auckland Bioengineering Institute. Results concur with those from Abaqus simulations, indicating that the prosthesis design is promising and could well be on the way for a successful introduction as a new alternative to knee replacement therapy.

The project resulted in a robust knee prosthesis that had undergone rigorous computational and experimental testing.

Kevin is now a Test Engineer with Orion Health.

Featured Alumni

Faisal Wahid, Class of 2011

I was hooked into modelling - the mathematical kind - in my final year of high school. I still remember attending the MAXX program and having Andrew Pullan teach us about multivariable calculus, and how it can be used to model human organs.

It was in my final year of EngSci that I found my passion for using maths to understand how we manage our rivers to generate electricity. My Part IV project was modelling the Waitaki River Scheme in order to determine if disaggregating the ownership of the hydro stations Tekapo A and Tekapo B would lead to mismanagement of one of our most precious resources, water. The project gave me my first exposure into New Zealand's electricity market, and got me hooked into this field.

It was natural that after graduating I went to work for Mighty River Power as a Trading Analyst. My day to day role involved carrying quantitative and qualitative analysis on the operations of Mighty River Power's generation portfolio and New Zealand's electricity market. Some of the highlights were working on models for producing optimal offers into the market, and models to efficiently operate hydro stations.

However my passion was always in hydro-river chain modelling, so I'm back to do a PhD. It focuses on developing models for optimising our rivers, and is in conjunction with EPOC and the Ecole Polytechnique in France. I am hoping to use stochastic models to capture the complexity of deciding how best to produce electricity from our waters, given the uncertain view of the future surrounding the state of the rivers and the state of the market. My future ambition is to understand the dynamics of rivers around the world with respect to electricity production, resource management and the economics of water.

Part II Field Trip 2013

by Simon Thomas, PII BME Rep

This year there were 72 of us - plus four fantastic DES staff - who travelled to Rotorua for the annual Engineering Science and Biomedical Engineering field trip.

On the way down to Rotorua those of us in BME visited Callaghan Innovations - a very interesting view into some upcoming technologies - and Orion Health, who showed us that creative spaces conducive to great products have a place in Auckland. The EngSci students visited Opus and Derceto - both prime (and exciting) examples of where a degree in engineering science can lead.

Thursday night saw the Engineering Science group cooking dinner for everyone - a seriously good entree of sausage sizzle followed by spaghetti bolognese and ambrosia finished it all off.

On Friday we all visited Contact Energy, where we were given a tour of the Wairakei geothermal fields and power station, organized and hosted by many DES graduates. Lunch was at the Rotorua Museum, followed by a tour and 'interactive' account of the 1886 Tarawera eruption. The BME crew were on dinner on Friday, also hosting Rosalind Archer. Beef, chicken and vegetarian stir fries, followed by chocolate mousse seemed to go down a treat - and there was nothing left by the end.

The Field Trip concluded on Saturday with a choice of either white water rafting (one raft flipped on the main waterfall, an event which was enjoyed by all, even the occupants), and a myriad of activities at Agroventures, an adrenalin-filled adventure park in Rotorua where participants braved the jet boat, giant swoop and the bungee!

The field trip was a fantastic way for us to get to know everyone - including a few of the staff - and has made it really easy for us to get along, leading to a fantastic first semester. We're all sure the rest will follow in the same fashion.

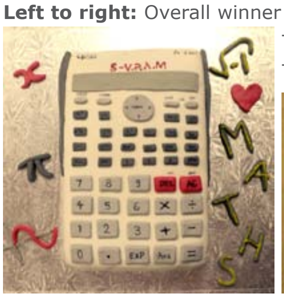
2013 BME vrs EngSci Bakeoff

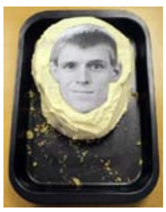
The theme was "What inspired you to do EngSci/BME?" There were 13 entries from 22 student bakers, including a strong contingent of Part II students - which was great to see. A huge number of supporters came to eat.

Part II EngSci student Ola Shahin took out the top 'Winning Whisk' award, along with Best EngSci Cake and People's Choice Presentation Award. Her entry was titled "I chose EngSci because of the maths involved. I love maths!", and was a black forest layer cake "with lots of sugar."

Best BME Cake was won by Michelle Windsor and Jenny Sahng for their entry "Phospholipid bilayer ATP synthase extravaganza", along with People's Choice Taste Award. The BME runners up were Melody Chen and Lysea Munro. The EngSci runner up, Part IV Marc Harris kept it from being a clean sweep for the Part IIs.

Patti Jessop-Pullan and Zeke Pullan (wife and son of Andrew Pullan) attended as part of the judging team, and handed out the awards.





Left to right: Overall winner & Best EngSci cake; Best BME cake; Jon Pearce (Professional Teaching Fellow) cake titled "No explaination required" by Simon Thomas, Ash Moorhead, Oliver Lin, Toby Jackson, who won the Wooden Spoon Award for their other entry, a Mother's Day cake from Countdown.

Sun, Sand and Silicone

by Matthew Davison, Part IV BME 2013

Over the summer I had the great pleasure of working with Locus Research on the Delloch hip protection project. The project as proposed was simple enough: investigate the current methods Delloch were using to test their hip protectors and build an alternative model that could be used for improved testing. I submitted a proposal involving a physical silicone model and a FEA computer simulation, and was fortunate enough to be granted an interview.

As I later discovered I was one of only two people granted an interview, which would normally have me clicking my heels in joy except that in a stomach churning twist the other person was a good friend of mine. Recognising the situation we had found ourselves in, we shook hands and agreed that whoever was chosen would owe the other pizza and beer. As of this date I have taken him out for pizza and I still owe him the beer.

So, at the beginning of December last year, I made my way to the Mount (making phone calls the whole way since I had failed to arrange accommodation for myself) and ultimately found my way to a cosy little caravan in a tree-shaded area, ten minutes' walk from work. Two days after that, I arrived at the Locus Research offices for the first time.

I must have looked very odd on that first day; rolling up in what was very nearly a suit and tie. Jono Jones, who would be my overseer on the project, laughed and called it a classic first day mistake. I quickly picked up the dress code at Locus, which is very much a relaxed one, and for the first time in my life I got used to wearing flip flops.

The pace of work at Locus was very different from the pace I had come to expect at university, where taking caffeine pills to work through the night, and then working all day afterwards was just something that happened sometimes. At Locus I got to experience sensible deadlines and reasonable project management for the first time, which was a delightful change.

Not that it was all relaxed of course. At the time that I proposed FEA for the project I had only performed simple-linear-elastic-noncontact-static simulations. I knew of course that what I was proposing was a more difficult nonlinear-hyperelastic-contact-transient simulation, but prior to the start of the project that seemed like a reasonable step up in difficulty. Looking back from the other side I can see that what I was effectively saying was equivalent to 'I can play golf, I think I'll play in the PGA world tour', and I soon fell back into my habit of working through the weekends.

But if the work was sometimes hard, the wonderful location of the office did a lot to make it better. I took to running around the Mount to clear my head at the end of the day, and found that I rather enjoyed long runs through nature. My fitness increased rapidly, from being pleasantly surprised to see the town again after circling the Mount to managing to follow the exceptional runners in the office staff as they led me on a meandering route up down and around the Mount, investigating everything short of the sheep tracks along the way.

I want to thank all the team at Locus Research for their help and fellowship during this time, and I hope that we will have the chance to interact in the future.

Photo: Matthew Davison (above left) and Timothy Allan, Locus CEO (above right). The articles on this page have been reproduced (with some edits) from the Locus Research blog with the kind consent of Locus, Matthew Davison, and Jono Jones. Matthew's original blog can be found at: locusresearch.com/blog/2013/02/26/sun-sand-silicone

Locus Research

Locus Research is an award winning New Zealand company which partners with businesses to develop new products and services, and bring them to market. Locus' client list includes companies such as Carter Holt Harvey, Louis Vuitton, and Fisher and Paykel Healthcare. For more, go to locusresearch.com.

FEA and device evaluation

The FDA have seen an increasing trend in simulation based submissions for medical devices, as engineers are achieving increasingly accurate levels of precision when evaluating device functionality previously not possible in physical testing.

Finite element analysis (FEA) is a computational process of dividing complex problems into many small sub-functions and solving each in relation to each other. This is typically used to analyse the stress and strain distribution through a part before it is manufactured. The use cycle of a part can be simulated within the software allowing for design optimisation based on how the part performs under stress. FEA is the interpretation of this complex information into useful information.

It is important to note that FEA is not a substitute for bench or human testing in the entirety. FEA models should, where possible, be calibrated against physical data derived from bench testing. This will mitigate risk upstream during in vivo (in living organism) testing.

FEA has proven to be a valuable tool for medical device development that can reduce time to market and hefty physical test costs. FEA can also unlock information previously unattainable by traditional physical test methods. In our world, this derives valuable insights that can lead to breakthrough product ideas. The acceptance of FEA in compliance submission adds further weight to use of simulation.

With funding support from the Ministry of Business, Innovation & Employment, we brought in Matthew Davison (DES) to explore the use of computational modelling and simulation to develop biomechanical apparatus used for testing hip protectors – a product we took to market in 2011.

The whitepaper released from this study describes how we used FEA to develop a surrogate soft tissue model used within apparatus to test hip protector devices.

The above is an extract from the Locus blog 'The digital body' by Jono Jones, Programme Director at Locus. For the full blog and whitepaper, go to locusresearch.com/blog/2013/04/23/digital-body

Demand response in electricity markets

by Golbon Zakeri

I arrived in NZ in 1995, with a joint PhD in Mathematics and Computer Sciences and my first challenge here was to balance the use of hydro and thermal resources for electricity generation for the state-owned ECNZ. The next year (1996) marked the transition of NZ to an electricity market paradigm. Since then, with some stints of exception that I spent back in the US, I have been preoccupied with NZ electricity market challenges.

The fundamental problem of electricity markets continues to be consumer participation. I have lately begun to take on this challenge. In 2010 I worked on the optimization of electricity consumption for our university together with Lesley Stone (Sustainability and Environmental Coordinator for the University of Auckland) as well as a group of summer students and other colleagues. In the same year my Part IV project student Jason Undan obtained first prize at the ORSNZ Young Practitioner Prize competition on his thesis titled "Optimisation of Demand Side Bidding".

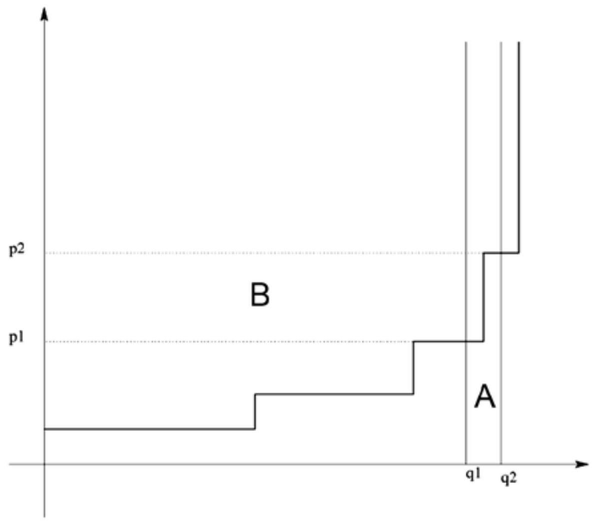
The key to understanding the importance of demand side participation in electricity markets is a good comprehension of how the market clears. In the NZEM generators offer in quantity-price pairs that constitute their generation offers for each trading period in the market (which is 30 minutes long). These quantity-price pairs are referred to as offer stacks and examples of such offer stacks are depicted below.

Just before the start of a period, with all generation offers intact and a good estimate of consumption available, Transpower solves an optimization problem that determines the efficient dispatch of generation, given the received offers and demand, as well as complying with network constraints (such as the location of generation units and demand, electrical line capacities and physical laws of electrical power flow). Along with this optimal dispatch, an economically efficient price of electricity is also determined. In our market, this price of electricity is variable from one node of the market to another and signals the relative importance of electricity savings at a location, for different trading periods.

For instance in periods of hydro shortage, the electricity prices climb dramatically, signalling the importance of electricity savings throughout the country. Also at times of peak usage, when electrical lines are constrained close to their capacity, particularly in the North Island, electricity prices reflect the importance of demand savings at locations at the endpoints of a line with limited capacity.

Consumer Response

Through responding to the price signals, any consumer of electricity, particularly a large industrial consumer, makes its operations cost effective and efficient. Large consumer response, however, has even more synergistic effects than are observed on the surface. When a large consumer responds to a high price signal by lowering its consumption, electricity prices also drop. This is illustrated in the diagram below. After the reduction of demand (by $\Delta q = q_2 - q_1$), the electricity price drops from p_2 to p_1. Notice that the (large) consumer's costs decrease by not only $\Delta q \times p_2$ (denoted by area A) but also by the drop in price for the quantity that they continue to consume (this is labelled area B) in the diagram.



Furthermore, the savings are not confined to the large consumer, rather the price is lowered across the electricity market. The fact that there is leverage to reduce consumption and we can take advantage of this leverage indicates that it is more efficient to reduce consumption and delay expensive investments. This is precisely what the lower prices of electricity would signal in the scenario that a large consumer has been able to respond to price. Overall such consumption reduction strategies would work towards making the electricity market much more efficient.

For the large consumers of electricity, we have now cracked the problem of period by period optimization of electricity consumption. The outstanding challenge is to design, for each large industry, its own suite of models that would utilize the period by period optimization to plan their dynamic production schedule. As I write this article I am preparing to travel to University of California Berkeley, where I will spend the next two months working with Professor Shmuel Oren on this very problem.

Commercial and residential users are also very much encouraged to participate in electricity markets. However models for their optimal participation hinge on different techniques and are the subject of a different article.