V. INDUSTRIAL PROGRAMME

Participants of the 6^{th} annual PIMS Industrial Problem Solving Workshop beside the PIMS facility at UBC.

PIMS/MITACS Industrial Partners

Advanis
Amber Computer Systems
APPEGA
Ballard Power Systems Inc.
Barrodale Computing
Bayer Inc.
BC Cancer Research Center
BC Hydro
BioTools
Canadian Cable Labs
Canadian Marconi
Charles Howards & Associates
Chemex Labs
Computer Modeling Group
Corel Corporation
Crystar Research Inc.
Diagnostic Engineering Inc.
Dynapro
Eastman Kodak
Enbridge
FinancialCAD Corporation
Firebird Semiconductors
Galdos Systems
Hughes Aircraft
Husky Oil
IBM T. J. Watson Research Center
ICBC
Imperial Oil
In Silico
Insightful
Itres Research Ltd.
Kinetek Pharmaceuticals Inc.
Lockheed Martin Tactical Defense Systems
Math Resources Inc.
MathSoft
MacMillan Bloedel Ltd.
McMillan-McGee
MDSI
Menex Technologies
Merak
Michelin
NALCO Canada Inc.
NORTEL Networks
Novacor
Pacific Forestry Centre
PanCanadian Petroleum Ltd.
Petro Canada
Progas
Powerex
Powertech Labs Inc.
Precision Biochemicals
Prestige Telecommunications
Progas
Quatronix Media
Searle
Shaw Cable
Siemens Research
Simons International Copr.
SmithKline BeeCham Pharma
Sperry-Sun
Soundlogic
StemCell Technologies Inc.
StemSoft Software Inc.
Stentor
Stern Stewart & Co.
Sun Microsystems
Syncrude
Telecom Research Labs
Telus
TransAlta
Veritas DGC
VisionSmart
Vortek Industries Ltd.
Waterloo Maple Inc.
Worker's Compensation Board

Industrial Problem Solving Programme

The format of the **Industrial Problem Solving Workshops** is mainly based on the Oxford Study Group Model, in which problems of relevant and current interest to the participating companies are posed to the workshop participants by experts from industry. The participating graduate students and academics will spend five days working on the problems and the results will be published in the workshop's proceedings. The advantages for participating students and academics are:

- The challenge of applying one's skills to new and relevant problems directly applicable to industry.
- The opportunity for continued collaboration with the workshop's academic and industrial participants.
- Help PIMS and mathematics in general, by showing businesses and governments the tangible benefits of supporting the mathematical sciences.

5^{th} PIMS Industrial Problem Solving Workshop (IPSW 5)

University of Washington, June 18–22, 2001

Organizers:
Randy LeVeque (U. Washington)
Chris Bose (U. Victoria)
Huaxiong Huang (York U.)
Marc Paulhus (U. Calgary)
Keith Promislow (SFU)
Ian Frigaard (UBC)

Industrial Participants:
Microsoft Research
Firebird Semiconductors
Communications Security Establishment
Alberta Energy Company
IBM
Algorithmics

6^{th} PIMS Industrial Problem Solving Workshop (IPSW 6)

University of British Columbia, May 27–31, 2002

Organizers:
Jack Macki (U. Alberta)
Chris Bose (U. Victoria)
Randy LeVeque (U. Washington)
Huaxiong Huang (York U.)
Marc Paulhus (U. Calgary)
Manfred Trummer (SFU)
Ian Frigaard (UBC)

Industrial Participants:
Capital Health
McMillan-McGee Corp
Precix Advanced Cutting Technologies
RBC Financial Group
Semiconductor Insights
Shell Canada
Talisman Energy

PIMS Industrial Problem Solving Workshop (IPSW 5), University of Washington, June 18–22, 2001

Organizers: Randy LeVeque (U. Washington), Chris Bose (U. Victoria), Huaxiong Huang (York U.), Marc Paulhus (U. Calgary), Keith Promislow (SFU) and Ian Frigaard (UBC).

Last year's **Industrial Problem Solving Workshop** (IPSW) was held at the University of Washington in Seattle. About 100 people registered for the event, including the 58 graduate students who had taken part in the graduate modelling camp the week before. Faculty from a number of universities around the world were also involved. Participants split up into six groups to attack the industrial problems brought to the workshop, spanning a broad range of applications and mathematical techniques. Most of the industrial participants were able to stay all week this year, and were actively involved in working with the groups. A brief description of the problems and some of the progress made is given below. More complete problem descriptions may be obtained from the website, **www.pims.math.ca/industrial/2001/ipsw**.

Workshop Problems:

Disk Layout Problem: Representing local Seattle industry, **John DeTreville** brought a problem from **Microsoft** on optimizing the layout of files on a disk, given an expected order in which the files will be accessed. The group learned a great deal about the complex details involved in hard drive technologies. They also quickly established that the problem was equivalent to the intractable Travelling Salesman Problem. After building some one- and two-dimension disk models, they applied various heuristic techniques to try to find the optimal solution for some sample data that Microsoft provided. It was concluded that the heuristic methods appear to provide better solutions more quickly using the 2-D model than with the 1-D model, suggesting that the more realistic 2-D (or the even more realistic 3-D model not studied) should be used when disk performance is critical. Current hardware limitations make the 1-D model the industry standard.

Model For InSb Czochralski Growth: Many of the participants who specialize in continuous modelling were attracted to the problem presented by **Bill Micklethwiate** of **Firebird Semicondutors**, arising from growing large single crystals of Indium Antimonide (InSb) from a melt. These crystals, about the size of a wine bottle, may develop imperfections due to thermal stresses as they cool. This problem contained something for everyone in continuum mechanics – fluid dynamics coupled with convective, diffusive, and radiative heat transfer, Stefan problems for the moving phase boundary, and temperature-dependent stress analysis within the solid phase. This group split into several subgroups to tackle various aspects of the problem by both analytical and numerical approaches. Some new insights were gained into the expected shape of the moving boundary and the relative importance of different heat-transfer mechanisms.

Network Search Theory: **Allan Douglas** from the **Communications Security Establishment** brought a problem relating to computer security on the large computer networks, such as the internet. Mobile software objects that move around between computers are becoming more common and the problem concerns the ability of the "good guys" to track down malicious software of this form. This led to an extensive literature search on problems of graph searching and random walks. The group discovered a vast and richly developed literature that was directly applicable to the problem at hand. They then expanded on that literature and established some new results based on the particulars of the problem.

Decline Analysis: **Ron Forth** presented a problem from the **Alberta Energy Company** on decline analysis, attempting to extrapolate trends in production rate data from oil and gas wells to forecast future production. The current practice is for a petroleum engineer to perform the extrapolation using visual curve fitting biased heavily by personal experience. The data is typically very noisy and has the additional feature that physical parameters in operation during the period of data collection are randomly changing (changes to pumping schedules, shutdowns, production enhancement, etc) so no one model can be expected to fit the entire time series. The workshop group concentrated on three aspects of the problem. First, the partitioning of the time series into intervals over which one physical model may be applied. Moving average and wavelet techniques were investigated; both seemed sufficient to perform the partition, provided reasonable thresholding values were used. Second, a curve fitting over each subinterval was performed. This was fairly straightforward as physical considerations lead to a parametric family of model curves and a simple, weighted, least-squares fit within that family appears to suffice. Finally a weighting of the various

extrapolations obtained in the previous step determines the final decline curve estimate. A heuristic weighting scheme was proposed and tested with reasonable results on a restricted data set. The possibility that this last step would lend itself to a neural-net approach was discussed.

Web Hosting Service Agreements: **Alan King** of **IBM** brought a problem on properly pricing web-hosting service agreements. A web-hosting service provider may have a large number of clients with different needs, and a finite amount of computer resources to distribute amongst those customers in order to satisfy certain Quality-of-Service (QoS) agreements. However, the web-hosting service can also dynamically reallocate its resources based on the observed needs of its clients at any given time. The team tackled this extremely complex problem and built a very realistic model taking into account a wide range of complexities such as requests of different size with different priorities, time-lag in the hardware re-distribution, as well as penalties for failing to meet the QoS agreements.

A Problem in Financial Mathematics: The final problem came from **Algorithmics**, a financial mathematics firm. **Alex Kreinin** presented a problem on measuring the credit risk of a given portfolio, based on the credit ratings of the obligors. Standard Monte-Carlo techniques do not work very well since the interesting events (default by the obligors) are very rare and hence require a large number of simulations. Algorithmics came to the workshop with a very well thought out model and everyone was pleasantly surprised that the group discovered an analytical solution based on using the Lindberg-Feller Theorem (basically the Central Limit Theorem in this context) to approximate the credit risk of all counterparties in a single (credit driver) scenario. This resulted in approximating the risk across scenarios by a mixture of Gaussians, the latter being one of the current methods for treating distributions with long tails. The group then proceeded to test this fast, approximate solution against much more time-consuming full Monte Carlo simulations for one time step. They found reasonable agreement and expect much better results for longer time horizons since the CLT is better suited when the number of independent random variables increases. This was viewed as a significant development in the important area of credit risk, and we look forward to seeing it developed further.

PIMS Industrial Problem Solving Workshop (IPSW 6), University of British Columbia, May 27–31, 2002

Organizers: Jack Macki (U. Alberta), Chris Bose (U. Victoria), Randy LeVeque (U. Washington), Huaxiong Huang (York U.), Marc Paulhus (U. Calgary), Manfred Trummer (SFU) and Ian Frigaard (UBC).

About 100 people registered for this year's **Industrial Problem Solving Workshop** (IPSW), including the 60 graduate students who had taken part in the graduate modeling camp the week before. Faculty from as far away as South Africa, Finland and China were also involved. Participants split up into six groups to attack the industrial problems brought to the workshop, spanning a broad range of applications and mathematical techniques. Most of the industrial participants were able to stay all week this year, and were actively involved in working with the groups. A brief description of the problems and some of the progress made is given below. More complete problem descriptions may be found on the website, **www.pims.math.ca/industrial/2002/ipsw/**, and proceedings papers are now being written by each group.

Workshop Problems:

Mathematically Surface Matching of Maps of the Human Torso: **Edmond Lou** represented **Capital Health** of Edmonton and brought a problem involving automating the process of analysis data from a 3D laser scanner that is used to diagnose patients with scoliosis. The current process, although good, relies on many manual user steps to complete the analysis. The team was able to show how some standard (and some not so standard) image processing techniques could be used to fully automate the data analysis process. Further, Capital Health was interested in knowing if it was necessary to use the physical marker points that they currently place on the patient's back before the scanning process. The team was convinced, after looking at a large amount of sample data, that the information given by the marker points could not be retrieved mathematically from the data, and hence are necessary.

Combined Inversion of Seismic and Magnetotelluric for Gas Exploration in the Canadian Foothills: **Kai Meunzer** from **Shell Canada** came to the workshop with an inverse problem: Given seismic and magnetotelluric data, can we determine geological properties of the Canadian foothill? After some discussion on the background materials of both seismic and magnetotelluric methodologies, the team realized that the best approach was to construct a simple one-dimensional 3-layer model to test a hybrid seismic-magnetotelluric approach by minimizing the weighted least square errors of both seismic and magnetotelluric data. Even though the team worked on this project was the smallest, each participant brought considerable expertise from various areas. With the help of Doug Oldenburg, (an expert in geophysical inverse problems), Yongji Tan, (an expert in inverse problems), and with the help of two graduate students, it was found that the hybrid method works better than either seismic or magnetotelluric approaches. This was only true if appropriate weight functions were chosen. Kai Meunzer was very satisfied with the progress made during the workshop and some follow-up work after the workshop has provided further insight into the problem.

How to create the composite image of an integrated circuit: **Edward Keyes** of **Semiconductor Insights** was interested in an algorithm to automatically stitch a large number of images of an integrated circuit together in order to reconstruct the image of the entire circuit itself. This problem attracted a large number of participants who quickly broke into teams to test the many different approaches that were suggested. The most straightforward approach, based on least-squares was implemented and tested during the week and was found to be a significant improvement over the current method. Other approaches, based on graph theory, simulated annealing and linear programming also showed a great deal of promise. It is clear that once the smoke clears the company will have an algorithm that is a significant improvement over the current techniques.

Resistance Monitoring: Appearing in his second IPSW, **Bruce McGee** of **MacMillan-McGee** presented the following scenario. One method of recovering soil contaminants is to electrically heat the soil with various electrodes inserted into wells in the ground. By injecting water into certain electrode locations and pumping fluids out of the remaining locations, the contaminants are slowly removed. If the contaminants are actually removed, as is intended, this process should change the resistivity of the soil as it progresses. For this reason, departures from the characteristic evolution of resistivity are of particular interest. The workshop participants were given the inverse problem of find the actual resistivity, given the response curve of the current, (or indeed any other measurable data). Failing this, was it possible to localize where in the domain any changes in resistivity occurred? Because of the size of the group (7 faculty and 9 graduate students), various aspects of the problem were investigated. To understand the forward problem a sequence of one and two-dimensional models were constructed to determine (i) the time evolution of the temperature field when cold water is injected and (ii) the sensitivity of the model to small localized changes in the resistivity. These preliminary investigations illustrated that an internal transition layer is generated during the propagation of the shock of injecting cold water, which persists in the steady state. Furthermore, the measured voltage between the electrodes is much more sensitive than the outflow fluid temperature to localized resistivity changes. Using these forward models as justification, the temperature field was neglected for the inverse problem and an attempt was made to implement the generalized sensitivity theorem in a square domain with a localized resistance anomaly at its centre. By combining the computed voltage field in the domain without the anomaly with a series of voltage measurements obtained with the anomaly in place, a picture of where the anomaly was located was built up. Work continues on the problem specifically in extending the analysis of the inverse problem to a simple layered medium. Investigations to increase the resolution of the inverse problem using an analytic Green's function and finite difference rather than finite element methods are ongoing. Bruce McGee was quite pleased with the progress made on the problem and anticipates a predictive model that can be used onsite. In Bruce's words, "It's all good!"

Price Pseudo-Variance, Pseudo-Covariance, Pseudo-Volatility, and Pseudo Correlation Swaps—In Analytical Close Forms: **Ritchie He** of the **RBC Financial Group** presented a challenge to compute the closed form solutions to some very complex "pseudo" statistics. The team for this problem consisted almost entirely of graduate students, most of whom were new to financial mathematics. Nevertheless, the result was achieved and we look forward to seeing the full solution presented in the report.

Seismic inverse problem in anisotropic, inhomogeneous media: In the areas of petroleum exploration and reservoir engineering, geoscientists use concepts from seismology to image the subsurface and determine essential rock-physics properties. Experimental conditions are typically in the form of a seismic survey whereby measurements are made of a seismic wave traveling between source and

receiver. **Talisman Energy** presented an inverse seismic ray problem that sought to incorporate recent technological advances in the determination of elastic moduli. In particular, with the development of three-component geophones it is now possible to measure particle displacement associated with a seismic wavefront at depth. Such an experiment, whereby sources are located at the surface and geophones are place within the earth, is called a VSP, (vertical seismic profile). It was hoped that pairing particle displacement (i.e., polarization angle) with recorded traveltime would lead to an in situ inversion for elastic modulii requiring only a single source/receiver pair. Using concepts of asymptotic ray theory and continuum mechanics the team was able to formulate a system of eight non-linear equations that could be solved for the elastic modulii that were sought. Unfortunately, with the introduction of experimental errors, the system proved highly unstable and had to be abandoned. However, with the introduction of some further, yet not overly restrictive, assumptions, the team went on to formulate a new system of four non-linear equations. Initial follow up work suggests the new formulation is reasonably stable under experimental conditions.

A Glimpse at 2003

7^{th} PIMS Industrial Problem Solving Workshop,
University of Calgary,
May 24–30, 2003

Workshop on Facility Location Problems,
SFU, June, 2003

Industrial and Scientific Training Activities

Basic Components of Programme:

The PIMS Graduate Industrial Mathematics Modeling Camp: Graduate students from Canadian universities come to learn various aspects of high-level techniques for solving industrial mathematics problems. The camp prepares them for the PIMS Industrial Problem Solving Workshop:

The PIMS Summer School in Industrial Fluid Dynamics: The participants attend a comprehensive series of graduate-level lectures and are also given hands-on experience performing and analyzing experiments in the Environmental and Industrial Fluid Dynamics Laboratory, as well as running numerical simulations using research-level codes.

The IAM-CSC-PIMS School in Industrial Mathematics for Senior Undergraduates shows students how the mathematics they are learning can be useful. Faculty mentors lecture on various industrial problems to all the participants. Subsequently, the students have the option of choosing one or more problems to work on during the three-day workshop.

The PIMS-MITACS-COE Undergraduate Industrial Case Study Workshop giving students in their senior year the opportunity to compete in a 3-day industrial case study competition.

The Industrial Workshops and Mini-courses with topics of interest to both industry and academia serve to disseminate newly developed mathematical tools that can be of use in industry. The workshops are more interactive than the mini-courses.

4^{th} PIMS Graduate Industrial Math Modeling Camp
University of Victoria, June 11–15, 2001
Coordinator: Chris Bose (U. Victoria)

5^{th} PIMS Graduate Industrial Math Modeling Camp
SFU, May 18–23, 2002
Coordinator: Marc Paulhus (U. Calgary)

3^{rd} PIMS Fluid Dynamics Summer School
PIMS at the University of Alberta, May 27–June 8, 2001
Organizers: B. R. Sutherland (U. Alberta) and T. B. Moodie (U. Alberta)

4^{th} PIMS Fluid Dynamics Summer School
PIMS at U. Alberta, July 28–August 9, 2002
Organizer: B. R. Sutherland (U. Alberta)

IAM-CSC-PIMS Senior Undergraduate Math Modelling Workshop
PIMS-UBC & PIMS-SFU, February 17–18, 2001
Organizers: R. Russell (SFU) & B. Shizgal (IAM)

IAM-CSC-PIMS Senior Undergraduate Math Modelling Workshop
PIMS-UBC & PIMS-SFU, February 16–17, 2002
Organizers: R. Russell (SFU) & B. Shizgal (IAM)

Statistical Genetics and Computational Molecular Biology Workshop
U. Washington, December 16–18, 2001
Organizer: Elizabeth Thompson (UWashington)

1^{st} PIMS Mathematics of Biological Systems Summer Workshop
University of Alberta, May 11–19, 2002
Organizer: Mark Lewis (U. Alberta)

PIMS-MITACS-COE Undergraduate Industrial Case Study Workshop
COE at UBC, May 25–27, 2002
Organizers: M. Puterman (Commerce and Business Admin, UBC) and Stephen Jones (COE, UBC)

Month of Industrial Math at PIMS: A wealth of opportunities for Canadian & US graduate students

The month of June 2001 witnessed a succession of scientific events in industrial mathematics at PIMS. More than 300 researchers, graduate students and senior undergraduates came from 25 Universities in Canada and the US to learn, research, interact, network and solve industrial problems at several interrelated events. The timetable was configured so that visiting students could participate in more than one of the worskhops.

The program started by the *PIMS-MITACS-Ballard Inc. Workshop on Computational Dynamic Fuel Cells* at Simon Fraser University held on June 4–8. This was organized in conjunction with the **PIMS Center for Scientific Computing**.

This was followed on June 9-10, by a PIMS-NSF-MITACS Workshop on *Inverse Problems and Imaging* at the PIMS facility at the University of British Columbia. This was organized in conjunction with the **PIMS Center for Inverse Imaging and Applications**.

Between June 11–15, the 4^{th} PIMS Graduate Industrial Mathematics Modelling Camp was held at the University of Victoria. This year, 20 US graduate students were admitted to the program in addition to the customary 40 Canadian participants. As usual, it was followed by the 5^{th} PIMS Industrial Problem Solving Workshop held this year at University of Washington in Seattle June 18–22.

4^{th} PIMS Graduate Industrial Math Modeling Camp, University of Victoria, June 11–15, 2001

Organizers: Chris Bose (U. Victoria), Randy LeVeque (U. Washington), Huaxiong Huang (York University), Mark Paulhus (U. Calgary), Keith Promislow (SFU) and Ian Frigaard (UBC).

From June 11–15, the University of Victoria hosted the fourth annual **PIMS Graduate Industrial Math Modelling Camp** (GIMMC). The students followed up with a second week of industrial mathematics at the IPSW in Seattle, June 18–22. A record 58 students attended the Camp, led by 8 academic mentors on a selection of industrial problems. This year's hardworking mentors were:

Sergei Bespamyatnikh (UBC)

John Chadam (U. Pittsburgh)

Ian Frigaard (UBC)

Lisa Korf (U. Washington)

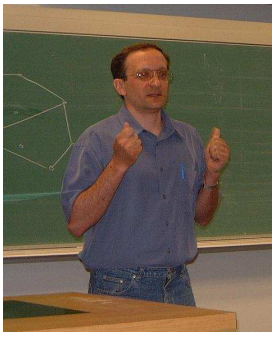
Hedley Morris (San Jose State)

Tim Myers (U. Capetown)

Miro Powojowski (Algorithmics Corp.)

Moshe Rosenfeld (U. Washington)

The problems examined over the course of the programme were:



Sergei Bespamyatnikh (UBC)

- Problems in Portfolio Analysis
- Locating Watchtowers in Terrains (PDF)
- Modelling a metal spray forming process
- Web-hosting Service Agreements
- Defect analysis using Depth from Defocus methods
- Modeling Ice Accretion
- Risk Neutral Probability Measure
- Optimal Control of Streetlight Networks

As with previous camps, students from all regions of Canada were eligible to attend. This year the programme was expanded to include 60 invited participants, up from the usual cap of 40. Further, in recognition of our newest PIMS institution, University of Washington, a special effort was made to attract students from US universities. In all, we had more than 130 applicants to the Camp, and we

accepted participants representing 25 North American Universities. Thirty-nine participants were from Canada and the remaining 19 were from the United States. Many favourable comments were collected from our mentors attesting to the excellent academic preparedness and to the enthusiasm of the students.

5th PIMS Graduate Industrial Math Modeling Camp, Simon Fraser University, May 18–23, 2002

Organizers: Jack Macki (U. Alberta), Chris Bose (U. Victoria), Randy LeVeque (U. Washington), Huaxiong Huang (York U.), Marc Paulhus (U. Calgary), Manfred Trummer (SFU) and Ian Frigaard (UBC).

At the **5th Annual Graduate Industrial Math Modelling Camp** (GIMMC) camp 60 graduate students from all over Canada, the US and even some from as far as Europe cut their teeth on some problems in Industrial Mathematics presented by prestigious academic mentors.

Brett Stevens (Carleton University) presented a problem in software testing. The idea was to apply combinatorics and statistical design to devise the best possible set of tests for a piece of abstract software. The students worked very hard devising combinatorial coverings of the space of possible input parameters.

Tim Myers (University of Cape Town) presented a problem on heating an airplane wing in order to evaporate water before it freezes. His students made great progress in modelling and solving this challenging thin film problem.

Chris Budd (University of Bath) presented a problem where you use a prod to test for the freshness of fish. His students were challenged into building a mathematical model the fish prods response and attempting to infer what information on the freshness of the fish could be retrieved from the data.

Yongji Tan (Fudan University, Shanghai) presented a problem applicable to the oil and gas industry. The students were asked to investigate the results of a well log tool that measures the resistivity in the surrounding structure. The students learned a great deal about finite element methods.

Alexander Melnikov (University of Alberta) came with some problems in financial mathematics. His problem attracted the largest number of students who were interested in learning about hedging and option in both complete and incomplete market settings.

Petra Berenbrink (SFU) brought her students right to the very edge of research in the complex area of routing in ad-hoc networks. The students came up with many new approaches and some counter-examples to this very difficult problem.

Brian Wetton (UBC) challenged the students with a very complex problem in modelling a protein membrane of a fuel cell. His students did an excellent job of solving some very difficult mathematics.

This year the students had a unique opportunity to present the results of the week's work in the form of a poster at the MITACS-AGM.

3rd PIMS Fluid Dynamics Summer School, PIMS-U. Alberta, May 27–June 8, 2001

Organizers: B. R. Sutherland (U. Alberta) and T. B. Moodie (U. Alberta)

Eighteen graduate students from all over the world attended a comprehensive series of lectures, and were given hands-on experience performing and analyzing experiments in the Environmental and Industrial Fluid Dynamics Laboratory, as well as running numerical simulations using research-level codes. Topics included fluid dynamics fundamentals, industrial and environmental flows, geophysical fluid dynamics, turbulence modelling and computational fluid dynamics. Subjects were all taught at a graduate level.

This year's summer school was particularly rewarding for the students since it was held in conjunction with a PIMS Thematic Programme on Wave Phenomena and Fluid Dynamics. Special invited speakers were T. G. Shepherd (Univ. of Toronto) who spoke on *The Fluid Dynamics of the Middle Atmosphere* and H. J. S. Fernando (Arizona State) who spoke on *Turbulence and Mixing in Stably Stratified Fluid Layers.*

The Core Lecturers for the courses were **John C. Bowman** (U. Alberta), *Turbulence Modelling*;

Andrew B. G. Bush (U. Alberta), *Climate Modelling*; **Peter Minev** (U. Alberta), *Computational Fluid Dynamics*; **T. Bryant Moodie** (U. Alberta), *Wave Theory*; **Bruce R. Sutherland** (U. Alberta), *Stratified Flows* and **Gordon E. Swaters** (U. Alberta), *Physical Oceanography*.

4th PIMS Fluid Dynamics Summer School, PIMS-U. Alberta July 28–August 9, 2002

Organizers: B. R. Sutherland (U. Alberta) and T. Bryant Moodie (U. Alberta)

A knowledge of the dynamics of fluids is the starting point to understanding such diverse fields of study as aerodynamics, weather forecasting, ventilation, lubrication and turbulence. Fluid flows can be described by mathematical equations but these cannot be solved except in special circumstances. Instead scientists solve the equations numerically or use the results of laboratory experiments to guide their intuition in finding solutions.

In its dedication to the training of highly qualified personnel, each year the PIMS sponsors a fluid dynamics summer school at the University of Alberta. The two week long event is attended by graduate students and senior undergraduates from around the world. Each morning the participants attend lectures on a broad range of topics including waves and turbulence, convection, physical oceanography and climate modelling. The afternoons are spent gaining hands-on experience running numerical simulations and performing laboratory experiments which are designed to complement the lectures and which are adapted from the lecturers' current research. At the end of the school the students give presentations based on the results of their work.

There are two other annual fluid dynamics summer schools in the world, one at the University of Cambridge, England and the other at Woods Hole Oceanographic Institution, MA, USA. The PIMS Fluid Dynamics Summer School is unique in its emphasis on computational fluid dynamics and computer-aided laboratory measurements. Indeed, with its modern computational resources and its concentration of expertise in experimental and numerical fluid dynamics, the U. Alberta is one of the few institutions in the world capable of running a school which simultaneously exposes participants to theory, numerical and experimental methods.

The summer school was fully attended by eighteen participants from Canada, England, Germany and the United States. Core lectures were given by **John Bowman** (Turbulence Modelling), **Andrew Bush** (Climate Modelling), **Peter Minev** (Computational Fluid Dynamics), **Bryant Moodie** (Wave Theory), **Bruce Sutherland** (Stratified Flows) and **Paul Myers** (Physical Oceanography).

The four invited lecturers were:

John Allen (U. Oregon): *Coastal Oceanography*

John Bush (MIT): *Geophysical Plumes*

Jean-Luc Guermond (LIMSI, U. Paris, Orsay): *Large Eddy Simulations*

Peter Rhines (U. Washington): *Overturning Circulations in the Oceans and Atmospheres* and *Montainous Flows in Rotating Fluids: Vorticity Dynamics, Form Drag and Induced Circulation*

Please see **http://fdss.math.ualberta.ca**.

2002 Fluid Dynamics Summer School participants.

IAM-CSC-PIMS Senior Undergraduate Math Modelling Workshop, PIMS-UBC and PIMS-SFU, February 17–18, 2001

Organizers: Bernie Schizgal (UBC) and Bob Russell (SFU)

The annual SFU-UBC-PIMS Senior Undergraduate Math Modelling Workshop was held on February 17 and 18, with Saturday's portion organized

by UBC's **Institute for Applied Mathematics** and Sunday's by SFU's **Centre for Scientific Computing**. The students came from across Canada — Acadia, University of Western Ontario, University of Alberta, University of Calgary, University of British Columbia, Memorial University of Newfoundland, McGill University, University of Toronto, York University, and SFU.

On Saturday, the students were given the choice of working on one of three projects: *Nonlinear Heat Conduction in the Microwave Heating of Ceramics* with Michael Ward (Math, UBC), *An Analytical and Numerical Study of Solitary Waves (Solitons)* with Bernie Shizgal (Chemistry, UBC and Director of the Institute for Applied Mathematics) or *Modelling the Flight Path of a Softball* with Douw Steyn (Earth and Ocean Science, UBC).

On Sunday, the students were given the choice of participating in one of two projects: *Liquid Mobility in Fuel Cells* run by Keith Promislow (Math, SFU) with help from Ron Haynes (Math Ph. D. student at SFU) or *Visualizing A Snowstorm* run by Dave Muraki (Math, SFU) and Torsten Moeller (Computing Science, SFU).

Both days of the workshop were highly successful, with the mentors being rewarded by an enthusiastic and lively response from the students. For more information, see **pims.math.ca/industrial/2001/suimw**.

IAM-CSC-PIMS Senior Undergraduate Math Modelling Workshop, PIMS-UBC and PIMS-SFU, February 16–17, 2002

Organizers: Bernie Schizgal (UBC) and Bob Russell (SFU)

The PIMS along with the Institute of Applied Mathematics (IAM) at the University of British Columbia and the Centre for Scientific Computing (CSC) at Simon Fraser University sponsored an undergraduate workshop on problems in applied mathematics for senior undergraduate students.

The workshop ran for two days with the first day at UBC and the second day at SFU.

Faculty mentors outlined each of the applied problems to all the participants. The students then chose one of the problems to work on each day. The mentors presented lectures in which the tools for the modelling and analysis of the problem were developed. The mentors then helped groups of approximately 8 students to develop the models and to answer the questions posed. The workshop culminated with a brief presentation by each of the groups working on the chosen problems.

The mathematical tools used in the workshop are accessible to 3rd and 4th year undergraduates in mathematics, applied mathematics, physics and applied science. The workshop is an opportunity to meet students from across Canada.

The Student Committee of the Canadian Mathematical Society sponsored Saturday's reception, the Department of Mathematics at SFU sponsored Sunday's dinner.

The problems discussed included:

Setting Stable Cement Plugs in Oil Wells, Mentor: **Ian Frigaard** (UBC)

Characterization of Internet Traffi c and its Impact on Network Performance, Mentor: **Ljiljana Trajkovic** (SFU)

Finding the tumor, Mentor: **Anthony Peirce** (UBC)

Scientifi c Visualization of Large Data Sets, Mentors: **David Muraki** and **Torsten Möller** (SFU)

For further details, please see the webpage **www.pims.math.ca/industrial/2002/summw**.

Participants in the IAM-CSC-PIMS Senior Undergraduate 2002

Statistical Genetics and Computational Molecular Biology, University of Washington, December 16–18, 2001

Organizer: Elizabeth Thompson (U. Washington).

This successful three-day workshop was aimed at students from the mathematical, computational, and statistical sciences who may be considering graduate study and research in these areas of mathematical

and computational biology. It was organised by the programmes in Statistical Genetics and Computational Molecular Biology at the University of Washington.

PIMS awarded a total of 13 travel scholarships to students from SFU, UBC and U. Calgary.

The following people spoke at the workshop:

David Baker (UW): *Protein Structure Prediction*

Jenny Bryan (UBC): *Finding Informative Subsets of Genes*

Joe Felsenstein (UW): *Trees of genes within and between species: molecular biology meets population biology*

Jinko Graham (SFU): *Testing and Estimation of Recombination Breakpoints in a Set of Aligned Sequences*

Phil Green (UW): *Analyzing Genome Sequences*

Kathleen Kerr (UW): *Gene Expression Microarrays: Classical Statistics and Modern Genomics*

Charles Kooperberg (FHCRC): *Sequence analysis using logic regression*

Leonid Kruglyak (FHCRC):

John Mittler (Microbiology, UW): *Population genetics and dynamics of HIV-1 infection*

Stephanie Monks (Biostatistics, UW): *Studying the Genetics of Gene Expression*

Maynard Olson (Genome Center, UW): *Resequencing Segments of the Human Genome: Experimental and Statistical Considerations*

Ram Samudrala (Microbiology, UW): *Modelling genome structure and function*

Elizabeth Thompson (Statistics, UW): *Inferring Gene Locations from Genetic Data on Pedigrees*

Martin Tompa (Computer Science and Engineering, UW): *Discovering Regulatory Motifs in DNA Sequences*

Ellen Wijsman (Division of Medical Genetics, School of Medicine, UW): *Gene fi nding in human populations*

1st PIMS Mathematics of Biological Systems Summer Workshop University of Alberta, May 11–19, 2002

Organizers: Mark Lewis (U. Alberta)

From May 11–19, 2002, the Centre for Mathematical Biology (CMB) offered the 1st annual PIMS Mathematical Biology Summer Workshop entitled **Mathematics of Biological Systems**. Our aim was to introduce undergraduate mathematics students to mathematical modeling and analysis applied to real biological systems. Instructors were Gerda de Vries, Thomas Hillen, Mark Lewis, and Michael Li, all from the University of Alberta. There was further assistance provided by volunteer graduate students, postdoc fellows, and staff (Robert Bechtel, Andrew Beltaos, Gustavo Carrero, Christina Cobbold, Tomas de Camino-Beck, Lisa Haraba, Annemarie Pielaat, Shirley Mitchell).

The participants.

We received applications from almost 40 students from all over North America. In the end, 26 students came to the workshop from 14 different Universities across Canada and the United States, many on their own funding. More than half of the attendees were women.

The workshop was 8 days in length and was a combination of classroom instruction, computer lab instruction and exercises, guided group project work, and project presentations.

The extremely positive feedback that was received, in combination with the large number of applicants and participants, has led us to pursue the workshop as an annual event. We strongly believe the exchange of ideas and knowledge that occurred between students will be carried back to their home universities and that the program will grow in popularity over the years to come.

PIMS-MITACS-COE Undergraduate Industrial Case Study Workshop, Centre for Operations Excellence, UBC, May 25–27, 2002

Organizers: Martin Puterman and Stephen Jones (UBC)

Sixteen undergraduate students in commerce, engineering, business, physics, mathematics, statistics, and computer science were invited from across Canada to meet industry executives and renowned academics, and to explore graduate study opportunities, and to work in teams to solve challenging business problems.

The focus of the workshop was a real-world case study competition, culminating with teams presenting their findings to industry executives and academics on May 27.

Universities represented in the workshop were UBC, SFU, U. Alberta, U. Calgary, McGill and Mount Allison. Workshop judges Glen Darou (COE Director, Industry), Carol Leacy (Vice President, Systems and Process Integration, Mark Anthony), Bernard Lamond (Professor and Director, Department of Operations and Systems, Universit Laval) and Maurice Queyranne, (COE Director, Academic) were presented with outstanding presentations from the workshop teams. All participants were awarded with certificates and COE sweatshirts for their excellent work over the weekend. Team four, composed of Derrick Chung (McGill), Amir Motamedi (McGill), Igor Navernioukk (UBC), and Philip Seo (UBC), was honored with the prize for "Best Overall Case Analysis and Presentation".

This workshop was designed to:

- Introduce students to current research initiatives and industrial problems in the operations research sector.
- Provide a unique opportunity for students to work in teams to solve challenging problems with mathematical and business content.
- Allow industry executives the opportunity to become acquainted with students and evaluate them for potential future employment.
- Inform students of the exciting opportunities for graduate studies in applied math and operations research.

For more information see the web page **www.pims.math.ca/industrial/2001/uicsw**.

A Glimpse at 2003

IAM-CSC-PIMS Senior Undergraduate Math Modelling Workshop, UBC and SFU, February 15–16, 2003

6th PIMS Graduate Industrial Math. Modelling Camp, BIRS, May 17–22, 2003

2nd PIMS-MITACS-COE Undergraduate Industrial Case Study Workshop, UBC, May 2003

2nd PIMS Mathematics of Biological Systems Summer Workshop, U. Alberta, May 2003

MITACS: A Network of Centers of Excellence in the Mathematical Sciences

Mathematics of Information Technology and Complex Systems (MITACS) is one of the three Networks of Centers of Excellence (NCE) created in 1998. The MITACS NCE is a joint venture of the three Canadian mathematical sciences institutes: the Centre de Recherches Mathématiques, the Fields Institute in Mathematical Sciences and the Pacific Institute for the Mathematical Sciences. MITACS harnesses mathematical power for the benefit of the Canadian economy. The network brings together more than 150 researchers at 22 Canadian universities with more than 70 Canadian industrial, medical, and financial organizations. The network comprises 23 projects addressing problems in five sectors of the Canadian economy, including two new projects funded in 2000.

The creation of the MITACS network provides an exceptional opportunity for the mathematical sciences community to develop a large scale systematic programme for research, HQP training and the development of partnerships with key business, industrial and health care sectors across the country.

Arvind Gupta, MITACS Programme Leader

3rd MITACS Annual General Meeting: Statistics for Large Scale Industrial Modelling, UBC, May 23–25, 2002

This meeting was part of the **PIMS Thematic Programme on Selected Topics in Mathematical and Industrial Statistics**.

See the chapter on *Thematic Programmes*.

MITACS Projects at PIMS

There are 31 ongoing MITACS projects across the country in five themes: Biomedical Research, Commercial Research, Information Technology Research, Manufacturing Research, and Trading and Finance Research. Here are the currently 14 projects coordinated by PIMS:

Biomedical Research

Biomedical Models of Cellular and Physiological Systems in Health and Disease

Leader: Dr. L. Keshet (Math, UBC)

Members: Dr. G. de Vries (Math, UA), Dr. D. Finegood (Kinesiology, SFU), Dr. R. Miura (Math, UBC), Dr. J. Piret (Biotech Lab, Chemical Eng, Bioresource Eng, UBC), Dr. E.Puil (Pharmacology, UBC) Dr. D. Schwarz (Research Director, Dept of Surgery, UBC), Dr. C. Shaw (Opthalmology, UBC), Dr. Y. Xian Li (Math, UBC) Dr. M. Mackey (Math, McGill)

Industrial Affiliates: Bayer Inc., InSilico Biosciences, Kinetek Pharmaceuticals, Precision Biochemicals, StemCell Technologies, SmithKline Beecham, BC Cancer Research Center.

Mathematical Modelling in Pharmaceutical Development

Leader: Dr. J. A. Tuszynski (Physics, U. Alberta)

Members: Dr. G. de Vries (Math, U. Alberta), Dr. G. A Dumont (Elec. & Computer Engg., UBC), Dr. M. Klobukowski (Chemistry, U. Alberta), Dr. B. MacLeod (Anaesthesia, Pharmacology & Therapeutics, UBC), Dr. J. Muldowney (Math, U. Alberta), Dr. K. Rubenson (CHET, Education, UBC), Dr. J. Samuel (Pharmacy & Pharmaceutical Sc., U. Alberta), Dr. Y. Tam (Pharmacy & Pharmaceutical Sc., U. Alberta), Dr. D. Wiens (Stats Centre, U. Alberta), Dr. D. Bevan, Dr. D. Quastel, Dr. C. Ries, Dr. M. Sutter, Dr. M. Walker, Dr. J. Wright

Industrial Affiliates: Drs. Y.K. Tam and D. Ridgway (Kinetana), Dr. R.R. Koganty (Biomira, Inc.), Mr. Willaim Gough (Universal Dynamics Technologies), Dr. Michael J. Ellison (Institute for Biomolecular Design), Dr. John Samson (MACI and Physics, U. Alberta), Dr. W. de Brouwer (Starlab, Belgium)

Other Affliates: Canadian-European Research Initiative on Nanostructure (Belgium), Drs. P.L. Christiansen and E. Mosekilde (Inst. of Math. Modeling, Danish Technical University), Dr. Y. Engelborghs (Biomolecular Dynamics, K. U. Leuven), Dr. M. Kimmel (Stats, Rice University), Jim Laukes (Psychology, U. Arizona), Dr. E. Unger (Molecular Biotechnology, Jena, Germany)

Commercial Research

Facility Location Optimization

Leaders: Dr. Binay Bhattacharya (CS, SFU) and Dr. David Kirkpatrick (CS, UBC).

Members: P. Bose (CS, Carleton U.), J. Han (CS, SFU), P. Hansen (Ecole des Hautes Etudes Commerciales/GERAD), J. M. Keil (CS, U. Saskatchewan), R. Ng (CS, UBC), T. Shermer (CS, SFU), J. Snoeyink (CS, UBC), G. Toussaint (CS, McGill U.)

Industrial Affiliates: Webdispatchers.

The Mathematics of Resource Allocation and Scheduling

Leader: L. Hafer (CS, SFU)

Members: B. Alspach (Math & Stats, SFU), J. M. Bourjolly (Concordia), W. Cunningham (C & O, U. Waterloo), L. Goddyn (Math & Stats, SFU), A. Gupta (CS, SFU), P. Hell (CS and Math & Stats, SFU), R. Krishnamurti (CS, SFU), W. Pulleyblank (Director, Math. Sciences, T.J.Watson Labs, IBM), M. Queyranne (Manag. Sci, UBC)

Industrial Affiliates: Amber Systems, HA Simons, IBM, Prestige Telecommunications

Probabilistic Mathematical Models for Complex Industrial Systems

Leader: M. Puterman (Commerce, UBC)

Members: D. Atkins (Commerce, UBC), J. Bookbinder (Waterloo), H. Chen (Commerce, UBC), M. Gendreau (Université de Montréal), S. Jones (Commerce, UBC), B. Lamond (Université Laval), T. McCormick (Commerce, UBC), J. McGill (Queen's U.), M. Queyranne (Commerce, UBC).

Industrial Affiliates: TELUS, Canadian Airlines International, Workers Compensation Board of BC.

Searching Networks

Leader: Dr. Brian Alspach (U. Regina)

Members: Gena Hahn (Montreal), Denis Hanson (Regina), Richard Nowakowski (Dalhousie)

Information Technology Research

Mathematical Methods for Modeling, Verification and Testing in Information Technology

Leader: Dr. Bruce Kapron (CS, U. Victoria)

Members: M. Cheng (CS, U. Victoria), J. Delgrande (CS, SFU), M. Greenstreet (CS, UBC), A. Hu (CS, UBC), P. Panangaden (CS, McGill)

Industrial Affiliates: Nortel Networks

Prediction in Interacting Systems (PINTS)

Leader: Dr. Mike Kouritzin (Math, U. Alberta)

Members: D. Blount (Math, Arizona State University), J. Bowman (Math, U. Alberta), P. Del Moral (Universite Paul Sabatier, France), D. Dawson (Fields), E. Gombay (Math, U. Alberta), A. Heunis (Engineering, Waterloo), T. Kurtz (Math, Wisconsin-Madison), J. Macki (Math, U. Alberta), L.Miclo (Universite Paul Sabatier, France), B. Remillard (École des Hautes Études Commerciales), J. Xiong (Math, U. Alberta)

Industrial Affiliates: Acoustic Positioning Research Inc., Lockheed Martin Canada, Lockheed Martin Naval Electronics & Surveillance Systems, VisionSmart

Quantum Computing

Leader: Dr. Richard Cleve (UBC)

Members: M. Mosca (C&O, Waterloo), J. Watrous (CS, Calgary), C. Crapeau (CS, McGill), R. Flamme (Physics, Waterloo), D. Lidar (Chemistry, Toronto) A. Tapp (CS, McGill), W. Unruh (Physics, UBC)

Symbolic Analysis

Leader: Dr. Peter Borwein (Math & Stats, SFU)

Members: F. Bergeron (Math, Université de Québec à Montréal), J. Borwein (Math & Stats, SFU), R. Corless (Math, UWO), S. Devitt (Waterloo Maple Inc), D. Jeffrey (Math, UWO), L. Jorgenson (Math & Stats, SFU), M. Lamoureux (Math & Stats, U. Calgary), M. Monagan (Math & Stats, SFU), J. Stafford (Math, UWO), S. Watt (Math, UWO)

Industrial Affiliates: Math Resources, Sun Microsystems, Waterloo Maple

Towards Interactive Data Mining

Leader: Dr. Raymond Ng (UBC)

Members: L. Lakshmanan (CS, UBC) A. Wagner (CS, UBC) R. Zamar (Stats, UBC) R. Miller (CS, Toronto) J. Rosenthal (Stats, Toronto) K. Sevcik (CS, Toronto)

Manufacturing Research

Mathematical Modeling and Scientific Computation

Leader: B. Wetton (Math, UBC),

Members: R. Bradean (PDF, Math, SFU) L. Bridge (Graduate student, Math, UBC) R. Choksi (Math & Stats, SFU), R. Haynes (Graduate student, Math, SFU) H. Huang (Math, York U.), N. Kouzniak (PDF, Math, UBC) M. C. Kropinski (Math & Stats, SFU), D. Liang (PDF, Math, York) M. Liang (Graduate student, Math, UBC) A. Novruzi (PDF, Math, UBC) A. Peirce (Math, UBC), K. Promislow (Math & Stats, SFU), B. Russell (Math & Stats, SFU), S. Ruuth (Math, SFU) B. Seymour (Math, UBC), J. Stockie (PDF, Math, SFU) M. Ward (Math, UBC), R. Westbrook (Math & Stats, U. Calgary)

Industrial Affiliates: Ballard Power Systems, Powertech Labs, Vortek Industries

Pseudo-differential Operator Theory in Seismic Imaging

Leaders: Dr. Michael Lamoureux and Dr. Gary Margrave (University of Calgary)

Members: R. Aggarwala (Math, U. Calgary), W. Allegretto (Math, U. Alberta), J. Bancroft (Geophysics, U. Calgary), P. Binding (Math, U. Calgary), K. Bude (Math, Washington), A. Calvert (Earth Sciences, SFU), P. Lancaster (Math, U. Calgary), L. Lines (Geophysics, U. Calgary) , E. Nyland (Physics, U. Alberta), M. Sacchi (Physics, U. Alberta), M. Slawinski (Mechanical Eng, U. Calgary), J. Sniatycki (Math, U. Calgary), G. Uhlmann (Math, Washington), D. R. Westbrook (Math, U. Calgary)

Industrial Affiliates: Chevron Petroleum Technology Company, Veritas DGC Inc, Consortium for Research in Elastic Wave Exploration Seismology

Trading and Finance Research

Modeling, Trading and Risk in the Market

Leader: U. Haussmann (Math, UBC)

Members: M. Barlow (Math, UBC), J. Friedman (Math, UBC), A. Lari-Lavassani (Math, U. Calgary), A. Peirce (Math, UBC), J. Walsh (Math, UBC)

Industrial Affiliates: Financial CAD, Powerex Corporation, Transalta

PIMS affiliated MITACS Postdoctoral Fellows 2002

1. Janez Ales, Simon Fraser University
2. Peter Berg, Simon Fraser University
3. Edgardo Cheb-Terrab, Simon Fraser University
4. Ronald Ferguson, Simon Fraser University
5. Daya Gaur, Simon Fraser University
6. Alexander Kononov, Simon Fraser University
7. Stefan Langerman, Simon Fraser University
8. Snezana Mitrovic-Minic, Simon Fraser University
9. Andrew Solomon, Simon Fraser University
10. Bettina Speckmann, Simon Fraser University
11. Brett Stevens, Simon Fraser University
12. Rong Ding, University of British Columbia
13. Marek Labecki, University of British Columbia
14. Stan Maree, University of British Columbia
15. Joern Sass, University of British Columbia
16. Rong Zhu, University of British Columbia
17. Hugh Geiger, University of Calgary
18. Peter Gibson, University of Calgary
19. Julien Arina, University of Victoria

A Glimpse at 2003

4^{th} MITACS Annual General Meeting,
Ottawa, May 8–11, 2003