Science Atlantic
connecting science education and research

# The 2016 Atlantic Universities Mathematics, Statistics and Computer Science Conference

**CAPE BRETON UNIVERSITY, SYDNEY, NS**

**OCTOBER 14TH – 16TH, 2016**

# CONFERENCE PROGRAM

AARMS

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# General Information

1. **Conference Location:** Most conference activities will be held in the CE building (number 17 and 19 on campus map). The Blundon Lecture will be in CE 258 Royal Bank Lecture on Friday at 7:00pm.

2. **Parking:** Please go to registration desk to pick up the parking pass (free) for Friday and Saturday. You must put the parking pass in your car and you can park in any lot. Please pay $1 for Sunday parking.

3. **Registration:** The registration desk is located in Great Hall of CE building and will be open from 11:00am to 12:30 pm, 1:30pm-3:00pm, 5:30pm-7:00pm on Friday, Oct. 14, and from 8:00am – 11:00am on Saturday.

4. **Competitions:** After visiting the registration desk, all CS programming competition participants should report to CE258 Royal Bank Lecture by 12:00pm. The competition will be held in B1022, B182, and B186 at 12:30pm. After visiting the registration desk, all Math competition participants should report to CE258 Royal Bank Lecture at 2:10pm.

5. **Pizza Party for all participants:** It will be held in Great Hall on Friday at 5:40pm.

6. **Reception:** The Reception will be held immediately following the Blundon lecture on Friday evening in Great Hall. A cash bar will be available.

7. **Banquet:** The Banquet on Saturday evening will begin at 6:30pm in the Multipurpose Room of CE building (number 15 on campus map).

8. **Internet Access:** Wireless Internet Access: You can connect guest@CBU. The username is library and the password is public1.

9. All presentation rooms are equipped with a Windows computer and white boards. If you are using an electronic presentation (PowerPoint or PDF only) please bring your files on a USB stick. You will not be able to use your own computer unless special permission is made.

10. **Bus Service:** Cape Breton Transit provides daily bus service from CBU to downtown every hour (beginning 8:20am and ending 10:20pm). The campus bus stop is located in the front of the Canada Games Complex (number 13 in campus map).

# Welcome

CAPE BRETON UNIVERSITY

Welcome to Cape Breton University and Cape Breton Island.

You have selected a beautiful time of year, as the deciduous trees change to the brilliant oranges, yellows and reds in contrast to the deep greens of the conifers. As well, culturally it is an active time, with the 20th edition of Celtic Colours International Festival in full swing this weekend.

Your program is full, from the programming competition, student talks and perhaps it is a nod to Celtic Colours, the math behind the sound of drums as a plenary lecture.

Enjoy the academic stimulation, the social networking and the hospitality of Cape Breton.

David McCorquodale,
Chair of Science Atlantic and
Dean of Science and Technology, Cape Breton University

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The Department of Mathematics, Physics and Geology

# Summary Schedule

**Friday, October 14, 2016 (for Science Atlantic committee members)**

| | |
|---|---|
| 3:00 – 4:00 | Joint Science Atlantic Committee Meeting (Math/Stats/CS), CE265 Sydney Credit Union Boardroom |
| 4:00 – 5:30 | Mathematics & Statistics Committee Meeting, CE261 |
| 4:00 – 5:30 | Computer Science Committee Meeting, CE265 Sydney Credit Union Boardroom |

**Friday, October 14, 2016 (for students)**

| | |
|---|---|
| 11:00 – 12:30<br>2:00 – 3:00<br>5:30 – 7:00 | Registration, CE Great Hall |
| 12:00 – 12:15 | Computer Science Programming Competition (gather together), CE258 (Royal Bank Lecture Hall) |
| 12:30 – 5:30 | Computer Science Programming Competition, B186, B1022, B182 |
| 2:30 – 5:30 | Mathematics Student Competition, CE258 (Royal Bank Lecture Hall) |
| 5:40 – 6:40 | Pizza Party for all attendances, CE Great Hall |
| 7:00 – 7:15 | Welcome Address, CE258 (Royal Bank Lecture Hall) |
| 7:15 – 8:15 | Blundon Keynote Lecture, CE258 (Royal Bank Lecture Hall) |
| 8:20 – 10:00 | Reception, CE Great Hall |

**Saturday, October 15, 2016**

| | |
|---|---|
| 8:00 – 11:00 | Registration, CE Great Hall |
| 8:20 – 8:40 | NSERC Scholarship Presentation |
| 8:40 – 9:20 | Contributed Talks (Math and CS students presentations) |
| 9:20 – 9:40 | Special Presentations (Math and CS professor presentations) |
| 9:40 – 10:10 | Nutrition Break |
| 10:10 – 11:10 | Sedgwick Keynote Lecture, CE258 (Royal Bank Lecture Hall) |
| 11:10 – 12:10 | Contributed Talks |
| 12:20 – 1:30 | Self-served Lunch at cafeteria |
| 1:40 – 2:40 | Contributed Talks |
| 2:40 – 3:00 | Nutrition Break |
| 3:00 – 4:00 | Field Keynote Lecture, CE258 Royal Bank Lecture |
| 4:00 – 5:20 | Contributed Talks |
| 6:00 – 8:30 | Banquet at Multipurpose Room in CE building |

**Sunday, October 16, 2016**

AARMS Session, 9:00-1:40, CE265 Sydney Credit Union Boardroom

# Detailed Presentations

## Friday Evening, Oct. 14

**7:00 – 7:15pm** **Welcome message, VP Gordon MacInnis**

**7:15- 8:15pm** **Blundon Lecture, CE258**
**Kabe Moen**

## Saturday Morning, Oct. 15

**8:20 – 8:40 am** **NSERC Scholarship Presentation**

**8:40 – 9:20 am** **Contributed Sessions**

| | Room CE325<br>CS Session | Room CE326<br>Math Session |
|---|---|---|
| 8:40 – 9:00 | Martin Main | Derek Blue |
| 9:00 – 9:20 | Hanjin Li | Katie MacEachern |

**9:20 – 9:40 am** **Special Session**

| | Room CE 325<br>CS | Room CE 258<br>Math |
|---|---|---|
| **9:20 – 9:40** | Shannon Ezzat | Daniel Silver |

**9:40 – 10:10 am** **Nutrition Break**

**10:10 – 11:10 am** **Sedgwick Keynote Lecture, CE258**
**Anne Condon**

**11:10 – 12:10 noon** **Contributed Sessions**

| | Room CE325<br>CS Session | Room CE326<br>Math Session |
|---|---|---|
| 11:10 – 11:30 | Finn Lidbetter | Jack O'Connor |
| 11:30 – 11:50 | Shael Brown | Alice Lacaze-Masmonteil |
| 11:50 – 12:10 | Sarah Thompson | Kody Crowell |

**12:20 – 1:30pm** **Self-served Lunch at cafeteria**

## Saturday Afternoon, Oct. 15

**1:40 – 2:40pm** **Contributed Sessions**

| | Room CE325<br>Graduage Session | Room CE326<br>Math Session |
|---|---|---|
| 1:40 – 2:00 | Emma Carlinze | Noah MacAulay |
| 2:00 – 2:20 | Ahmed Galila | Leah Genge |
| 2:20 – 2:40 | Sazia Mahfuz | Joshua Fleming |

**2:40 – 3:00 pm** **Nutrition Break**

**3:00 – 4:00pm** **Field Lecture, CE258**
**Hugh Chipman**

**4:00 – 5:20pm** **Contributed Sessions**

| | Room CE325<br>ACENET Session | Room CE326<br>Math Session |
|---|---|---|
| 4:00 – 4:20 | Milton King | Josh Feldman |
| 4:20 – 4:40 | Sarah Walsh | John Oliver MacLellan |
| 4:40 – 5:00 | Peter Lee | Marzieh Bayeh |
| 5:00- 5:20 | Anthony St-Pierre | Jordon Barrett |

## Sunday Morning, Oct. 16

## AARMS Session

## Partial Differential Equations: Regularity, Numerics, and Applications

| | |
|---|---|
| 9:00-9:30 | Kabe Moan |
| 9:30-10:00 | Theodore Kolokolnikov |
| 10:00-10:20 | Nutrition break |
| 10:20-10:40 | Scott Rodney |
| 10:40-11:10 | Mohammad Abu Zaytoon |
| 11:10-11:40 | Saleh Alzahrani |
| 11:40-12:10 | Sayer Alharbi |
| 12:10-12:40 | Heping Xu & George Chen |
| | |

# Keynote Speakers

## Blundon Lecture: Dr. Kabe Moen, University of Alabama

### Hearing the shape of a drum

Fifty years ago Marc Kac posed the question "Can you hear the shape of a drum?" Specifically, if you know all of the frequencies at which a planar region resonates can you deduce its shape? It took almost 30 years to answer Kac's question and there are several basic questions that are still open. We will survey some of the wonderful mathematics associated with hearing the shape of a drum.

Kabe Moen is an associate professor of mathematics at the (University of Alabama), Tuscaloosa (AL). Kabe has a wide variety of research interests ranging from harmonic analysis and partial differential equations to chess compositions. With a Simons Foundation grant supporting his work, Kabe's recent interests focus on weighted estimates in harmonic analysis and PDE. Kabe earned his B.A. in mathematics at William Jewell College (MO) in 2002, his M.A. in 2005 and Ph.D. in 2009 both from the University of Kansas, Lawrence (KS).

## Sedgwick Lecture: Dr. Anne, Condon, University of British Columbia

### Models and hardness results for predicting secondary structure and kinetics of interacting DNA strands

The field of molecular programming aims to build computing devices, such as logic circuits, by harnessing DNA's four-letter digital sequence and propensity for secondary structure formation via Watson-crick base pairing. DNA programs execute when sets of interacting molecules change structure over time, consistent with DNA kinetics. Accordingly, it is very useful to computationally predict DNA structure and kinetics, i.e., changes in structure over time. We'll describe our recent progress in developing computational models of DNA kinetics, as well as hardness results on the computational complexity of predicting secondary structure of multiple strands.

Anne Condon is Professor of Computer Science at the University of British Columbia. Her research interests are in the areas of theoretical computer science and biomolecular computation, with a current focus on ways to computationally predict and design nucleic acid structures. Anne received her Bachelor's degree from University College Cork, Ireland, and her Ph.D. at the University of Washington. She is an ACM Fellow and a Fellow of the Royal Society of Canada.

## Field Lecture: Dr. Hugh Chipman, Acadia University

### An Overview of Statistical Learning

Like machine learning, the field of statistical learning seeks to "learn from data". I will review some of the central ideas that identify statistical learning, including regularization and the bias-variance trade-off, resampling methods such as cross-validation for selecting the amount of regularization, the role of a probability model for data, and quantification of uncertainty. These ideas will be discussed in the context of popular recent approaches to supervised and unsupervised learning.

Hugh Chipman received his B.Sc. from Acadia University in 1990 and his M. Math and Ph.D. from Waterloo (1991, 1994). He is a P. Stat. Before joining the faculty at Acadia in 2004, he held faculty appointments at the University of Chicago and the University of Waterloo. He has served as the Statistical Society of Canada's Electronic Services Manager and local arrangements chair for the 2011 SSC meeting in Wolfville. He is President-Elect of the SSC. He has served the broader Statistical Sciences community as a member and chair of the NSERC Grant Selection Committee for Statistics and as Editor of Technometrics. He held a Canada Research Chair from 2004-14, has been awarded the CRM-SSC prize and is a fellow of the American Statistical Association. His research interests include statistical learning, computational statistics, industrial statistics and Bayesian methods.

# Special Presentations

## Math Presentation:

## Paths for Teaching Mathematics in Universities

**Dr. Shannon Ezzat, University of Winnipeg**

Many strong undergrad math students are drawn towards teaching mathematics at universities, though most of these students are unaware of all of the different paths that are available to them. Indeed, some of these paths towards university teaching are quite new and very few people have a good idea of what these paths entail.

We will explore the different types of teaching positions at universities, including professors, teaching professors, instructors, lecturers, and by-course sessional instructors. Our exploration will talk about what kind of work each position does, where the work is located, the educational requirements for each position, salaries and benefits, chance of being employed, and length of employment.

## Computer Science Presentation:

**A Scalable Unsupervised Deep Multimodal Learning System}**

**Dr. Daniel L. Silver, Acadia University**

We present an unsupervised multimodal learning system that scales linearly in the number of modalities. The system uses a generative Deep Belief Network for each modality channel and an associative network layer that relates all modalities to each other. The system is trained so as to reconstruct the output at all missing channels given input on one or more channels. The system uses a derivation of the back-fitting algorithm to fine-tuning just those weights leading to the associative layer from each channel. This allows the system to generate an appropriate representation at the associative layer and to scale linearly with the number of modalities. An experiment learning the numeric digits 0 through 9, from four sensory channels (audio, visual, motor and
Classification), demonstrates that the generative system can accurately reconstruct any channel from as few as one other channel.

# Contributed Presentations

**The Power Index Game** – Jordan Barrett, Dalhousie University

The power index game models a political committee in which a bill is proposed and party members vouch to pass or reject the bill. We use graphs to model different committees, where vertices represent members and edges represent friendships among members. The game takes place in rounds where in each round, members keep or change their decision on passing the bill based on the influence of their local neighbourhood. We will look primarily at cycles, and more importantly how we can get large cycles from contrived set ups.

**Lusternik-Schnirelmann category** – Marzieh Bayeh, Dalhousie University

The Lusternik-Schnirelmann category (LS-cat) of a topological space is a topological invariant defined to be the
smallest number of open sets that cover the space, with each open set contractible to a point in the whole space. We will discuss the LS-cat of various spaces and consider the relation between LS-cat and another invariant called topological complexity (TC). TC is a useful tool in robotic motion planning.

**The UV-to-X-Ray Spectral Energy Distribution of Active Galactic Nuclei**

- Derek Blue, Mount Saint Vincent University

Active Galactic Nuclei (AGN) are extremely luminous objects at the centre of many galaxies, thought to consist of rapidly accreting supermassive black holes. In this project, the X-ray spectra of several AGN were analyzed in a search for potential

correlations between the soft (low-energy) and hard (high-energy) X-ray wavelengths. Analysis of these spectra lead to the hypothesis that higher-luminosity objects tend to be more X-ray weak, that is, the soft part of the spectrum is more dominant compared to the hard part.

**On the mathematical structure of computer programs as data miners**
- Shael Brown, Dalhousie University

Not only are computer programs computational tools, but we can also look at them as mechanisms to obtain information about their input. Under this viewpoint, what kinds of properties and structure do they have? We develop algebraic structure in an attempt to formalize some of the intuition we have for programs in a data mining scenario.

**The spectral theorem behind hearing the shape of a drum** - Emma Carline, Dalhousie University

If we know the shape of a drum what can we say about the frequencies at which it vibrates? In this talk I will give a quick overview of the spectral theorem for compact self-adjoint operators on a Hilbert space and discuss how it helps answer this question.

**Modelling the Behaviour of Striped Bass in Minas Passage** - Kody Crowell, Acadia University

Tidal energy development in the Bay of Fundy has been an active area of research for the past few decades. Recently, the Cape Sharp Tidal project involving OpenHydro and Emera was approved by the government of Nova Scotia for the deployment of two turbines at the FORCE test site in Minas Passage. However, the ecological impact the turbines pose to the surrounding environment has sparked much interest, particularly among fishing associations native to the Bay of Fundy. As such, there has been an increased demand for monitoring and consultation. Several species, especially the Striped Bass (*Morone saxatilis)*, are known to spend a significant amount of time near the berth sites, and their level of activity may be dependent on the season - recent studies involving acoustic tracking of the fish suggest that the species has a lower metabolic rate in the winter, thereby limiting its ability to detect and avoid turbine infrastructure in time, acting as "inert" particles. Modelling the movement of such a species using agent-based models and the Finite Volume Community Ocean Model (FVCOM) in the Minas Passage is one way of predicting whether an animal will collide with a turbine. Individual-Based Models were used to model fish behaviour and suggest where Striped Bass might spend a majority of their time in the winter and summer seasons. The seasons differ in the availability of food in Minas Basin, the parameters of which was developed from observational data collected by marine biologists at Acadia. It was found that in the summer, Striped Bass tend to stay within the Basin to feed, while in the winter, they follow the flow much more, tending to end up in Minas Passage, and in particular, near the FORCE testing site. This is in general agreement with observation, which suggests that Striped Bass prefer deeper waters in colder weather. Future studies will include the addition of in-stream tidal turbines for the winter model.

**Popularity and Community: Using the Spatial Preferential Attachment Network to Model Infectious Processes** – Josh Feldman, Dalhousie University

Often contagious processes are studied on the microscopic level of person-to-person interactions or the macroscopic level of how the infection manifests itself in the entire population. This talk will use a graph theoretic approach to address some questions that lie in between, at the "mesoscopic level" of community structure. I will briefly discuss some common features of real-life networks and then describe the spatial preferential attachment model as a means to mathematically express these characteristics. We will then look at two infectious processes and study how the behaviour of highly connected vertices changes how the disease spreads with respect to community structure.

**An Introduciton To Hopf Algebras By Example** - Joshua Fleming, Memorial university

For a field k, a Hopf algebra H over k is a bialgebra with an additional map S called the antipode. Hopf algebras have found numerous applications in physics, combinatorics, non-commutative geometry, as well as other areas of algebra. We will briey examine what is a Hopf algebra. From there, the focus of this talk will be investigating examples of Hopf algebras through group rings, tensor algebras, and the Taft algebra.

**Supervised and unsupervised approaches to measuring usage similarity** - Milton King, University of New Brunswick, Fredericton

In order to represent the meaning of a document for Natural Language Process tasks such as translation, it is necessary to first represent the meaning of words. Natural Language Processing (NLP) is the field of automatically analyzing text for a variety of applications, including sentiment analyses, (rating a document as having positive or negative sentiment), machine translation, and spelling correction. An ongoing problem in NLP is developing a useful representation of words that will capture the meaning of each word. Many of the applications in NLP will improve its performance with a better representation of the meaning of words. Usage similarity is an approach to determining word meaning in context that does not rely on an external dictionary with predefined words. Instead, pairs of usages of a target word are rated on a scale for how semantically similar they are. We used a variety of models to represent the meaning of words for this task, where the meanings of the words are in the form of vectors called embeddings. The models that we applied to the task include models that embed the entire sentence, embed each word, and embed the context of a word. We present both unsupervised and supervised approaches to measuring usage similarity. We achieve state-of-the-art performance with our unsupervised models on two different datasets.

**Control Theoretic Formal Methods for Software Verification** - Finn Lidbetter, Mount Allison University

Consider a complex piece of software that will be released with multiple versions, each

with slightly different features. Unfortunately, it does not function as intended, but we have a mathematical model of exactly how the software should operate. The question we want to answer is whether or not the errors can be resolved by restricting access to certain parts of the software, based on the analysis of the mathematical model. We model the software as a modal transition system and introduce decentralized discrete-event control to perform the high-level verification. The progress that has been made in exploring this problem in the context of a control theoretic framework will be presented. This work builds on existing theory for simpler models and provides further theoretical grounding for the use of formal methods for software development.

**Escaping Local Minima with Symbols** – Admed Galila, Acadia University

Deep learning is part of machine learning that is inspired by how the human brain processes sensory input. The goal is to train predictive models (models that can predict patterns in new observations) using a hierarchal approach were each level is an abstract representation of the input.

Training such deep architectures involves exposing the model to a training set of observations and adjusting the configuration of the model in such a way as to minimize the error in the model's prediction. This presents a challenge since eventually the configuration will reach a point where further modification will not provide noticeable improvement in performance.

I am investigating ways to overcome this challenge. Specifically by introducing symbols that act as hints. This will allow the architecture to identify important features in the input that will eventually allow it to escape this optimization problem.

**Stochastic Domain Decomposition for Elliptic Grid Generation in Parallel** - Leah Selma Genge, Memorial University

A discussion on the basic concepts of approximating numerically a partial differential equation resulting from a physical system. We explore both deterministic and probabilistic methods for solving these problems and discuss the benefits of using stochastic processes combined with parallelization and domain decomposition to arrive at a competitive algorithm for similar problems.

**Symmetric Products and Involutions** - Noah MacAulay, Memorial University

In this talk, I will explain a few concepts, in increasing order of complexity:
--the product of topological spaces
--the symmetric product of a space with itself
--anti-symplectic involutions
--symmetric products fixed under an anti-symplectic involution
Finally, I will explain (sketchily) how this relates to solutions of the self-duality equations on a Riemann Surface, which is the program of research that Dr. Tom Baird and myself were pursuing this summer.

**Size Bounds for Peaceably Coexisting Armies of Queens** - Katie MacEachern , St.FX University

The problem of Peaceably Coexisting Armies of Queens, introduced by Robert Bosch as a “Mind Sharpener” problem in the June 1999 edition of Optima, involves placing two equal-sized armies of queens on an n by n chessboard so that no two queens from opposing armies can attack each other. The maximum size of the two armies is known for boards up to 11 by 11; however, bounds have not been established for larger boards. This presentation provides a construction which generates the best-known solutions for boards larger than 11 by 11 and establishes lower and upper bounds.

**An investigation into the regularity of Partial Differential Equations through Alscoff and Balance Conditions** - John Oliver MacLellan, Cape Breton University

We investigate the regularity of Partial Differential Equations through Alscoff and Balance Conditions. We improve upon the work of Rios, Korbobenko, and Maldonado by showing that a weak Sobolev Inequality implies a doubling property for the underlying measure.

**Machine Learning Effective consolidation in lifelong machine learning using deep learning architecture** - Sazia Mahfuz, Acadia University

Lifelong machine learning, or LML, is an area of machine learning research concerned with the persistent and cumulative nature of learning. LML considers situations in which a learner faces a series of examples (potentially from different tasks) and develops methods of retaining and using prior knowledge to improve the effectiveness (more accurate hypotheses) and efficiency (shorter training times) of learning. Our work focuses on the retention problem of LML. The objective is to develop a LML system that can consolidate new information into an existing machine learning model without catastrophically forgetting the old information. One approach is to perform task rehearsal where examples of the new task are interleaved with examples of the older tasks during training. This avoids the loss of prior knowledge while integrating in the new knowledge. However, this approach requires saving old training examples. We investigate a method of generating virtual examples of prior tasks from the existing LML model that represents the prior tasks. We use a Deep Belief Network approach that uses Restricted Boltzmann Machine layers to first develop unsupervised generative models of the input space. The intention is to use these generative models tocreate appropriate virtual examples for the prior tasks using random inputs.

**On the cordiality of various unions of complete graphs** - Alice Lacaze-Masmonteil, Acadia University

Cordial labeling is a binary graph labeling introduced by I. Cahit in an attempt to solve

the Graceful Tree Conjecture. A graph, *G*, is a structure comprised of a set of vertices, *V(G)*, and a set of edges, *E(G)*. The binary function f maps vertices of *G* to the binaries such that $v(i), i \in \{0,1\}$, denotes the number of vertices labeled *i*. Elements $e=xy \in E(G)$, $x,y \in V(G)$, are assigned binary weights under the following operation: $|f(x)-f(y)|$. Analogously to vertices, the number of edges labeled *i* is denoted *e(i)*. A graph is cordial if it can be labeled by *f* such that $|v(0)-v(1)| \leq 1$ and $|e(0)-e(1)| \leq 1$. Since its introduction, mathematicians have studied the cordiality of a wide array of graphs. However, investigating the cordiality of graphs built from a set of complete graphs has been particularly difficult. The only complete investigation of such structures is presented by Kuo et. al. (1994) regarding the cordiality of the graph *nKm*. Using some counting principles, their method converts cordiality conditions into a set of diophantine equations. Since then, little progress has been made regarding the cordiality of these graphs. Using graph operations, this talk extends said method to the study of regular windmills, path-unions, cycles and closed chains of complete graphs. We present a near-complete investigation of these structures, thus improving results presented in several papers.

**Dynamics and differentiability of certain self-maps of [0,1]** – Jack Carlton O'Connor, University of New Brunswick, Fredericton

For a given positive integer n, denote by A(n) the set of rational numbers in [0,1] which have denominator n in lowest terms. We discuss several early results on the behavior of continuous functions which permute the rationals, focusing on those which fix 0 and cyclically permute every A(n). Namely, their integrals are computed, their Hölder exponents are bounded above, and Sharkovsky's Theorem is applied in order to find periodic points, besides those which have already been assumed.

**Searching for Matrix Multiplication Algorithms** - Sarah Thompson, University of Prince Edward Island

Computing matrix products is one of the central operations in most numerical algorithms. Any improvement on the efficiency of matrix multiplication algorithms would have widespread applications. I will talk about our project to develop a strategic computer search for a more efficient matrix multiplication algorithm. (joint with Dr. Gordon MacDonald)

**Water Circulation in the Bras d'Or Lakes** – Sarah Walsh, Cape Breton University

The Bras d'Or Lakes is a complex estuarine system situated in the center of Cape Breton Island with over four hundred barrachois ponds surrounding the exterior. Vital for understanding water circulation in the Bras d'Or Lakes is understanding how the barrachois ponds contribute to the system. Understanding the circulation of the water in this system is critical in gaining a greater understanding of how water, nutrients, and larvae are transferred in the lakes. This will lead us to more accurate predictions when

determining the spread of diseases and species distribution. One way to see the contribution of the barrachois ponds is to determine residence time, the average amount of time a material spends in a reservoir. To aid in finding residence time data was collected from Irish Vale pond in the Bras d'Or Lakes and other variables were determined from weather archives and equations. Regression analysis was preformed from the data using several predictor variables and the inside water level of Irish Vale pond as the variable being predicted. Results of the regression illustrated that a split model depending on weather conditions best described the system.

# AARMS Session

**When does a function belong to the union of Lebesgue spaces?** – Kabe Moen, University of Alabama

We survey some basic facts about Lebesgue spaces. We show that the union of Lebesgue spaces is intimately related to the Hardy-Littlewood maximal function and the theory of weighted Lebesgue spaces -- Lebesgue spaces with a change of measure. We give several simple characterizations of when a function belongs the union Lebesgue spaces. This presentation will be based on a joint work with Greg Knese and John McCarthy.

**Spike distribution density in a reaction-diffusion system with spatial dependence** - Theodore Kolokolnikov, Dalhousie University

We consider a reaction-diffusion system (the Schnakenberg model) that generates localized spike patterns. Our goal is to characterize the distribution of spikes in space and their heights for any spatially-dependent feed rate A(x). In the limit of many spikes, this leads to a fully coupled nonlocal problem for spike locations and their heights. A key feature of the resulting problem is that it is necessary to estimate the difference between its continuum limit and the discrete algebraic system to derive the effective spike density. For a sufficiently large feed rate, we find that the effective spike density scales like $A^{2/3}(x)$ whereas the spike weights scale like $A^{1/3}x)$. We derive asymptotic bounds for existence of N spikes. As the feed rate is increased, new spikes are created through self-replication whereas the spikes are destroyed as the feed rate is decreased. The thresholds for both spike creation and spike death are computed asymptotically. We also demonstrate the existnence of complex dynamics when the feed rate is sufficiently variable in space. For a certain parameter range which we characterize asymptotically, new spikes are continously created in the regions of high feed rate, travel towards regions of lower feed rate and are destroyed there. Such "creation-destruction loop" is only possible in the presence of the heterogenuity.

**The Poincare Inequality and the p-Laplacian** – Scott Rodney, Cape Breton University

In this talk I will explore a necessary and sufficient condition for the validity of a Poincare - type inequality. This work will be presented in the context of the degenerate

Sobolev spaces $W_Q^{1,p}(\Omega)$ and the Degenerate *p*-Laplacian given by

$$\Delta_p u = \mathrm{Div}\left( \left| \sqrt{Q(x)} \nabla u(x) \right|^{p-2} Q(x) \nabla u \right)$$

where *Q(x)* is a non-negative definite $L^1_{loc}$ matrix valued function.

**Flow Down an Inclined Plane of a Fluid with Pressure-Dependent Viscosity through a Porous Medium with Variable Permeability** - S.M. Alzahrani and M.H. Hamdan , University of New Brunswick

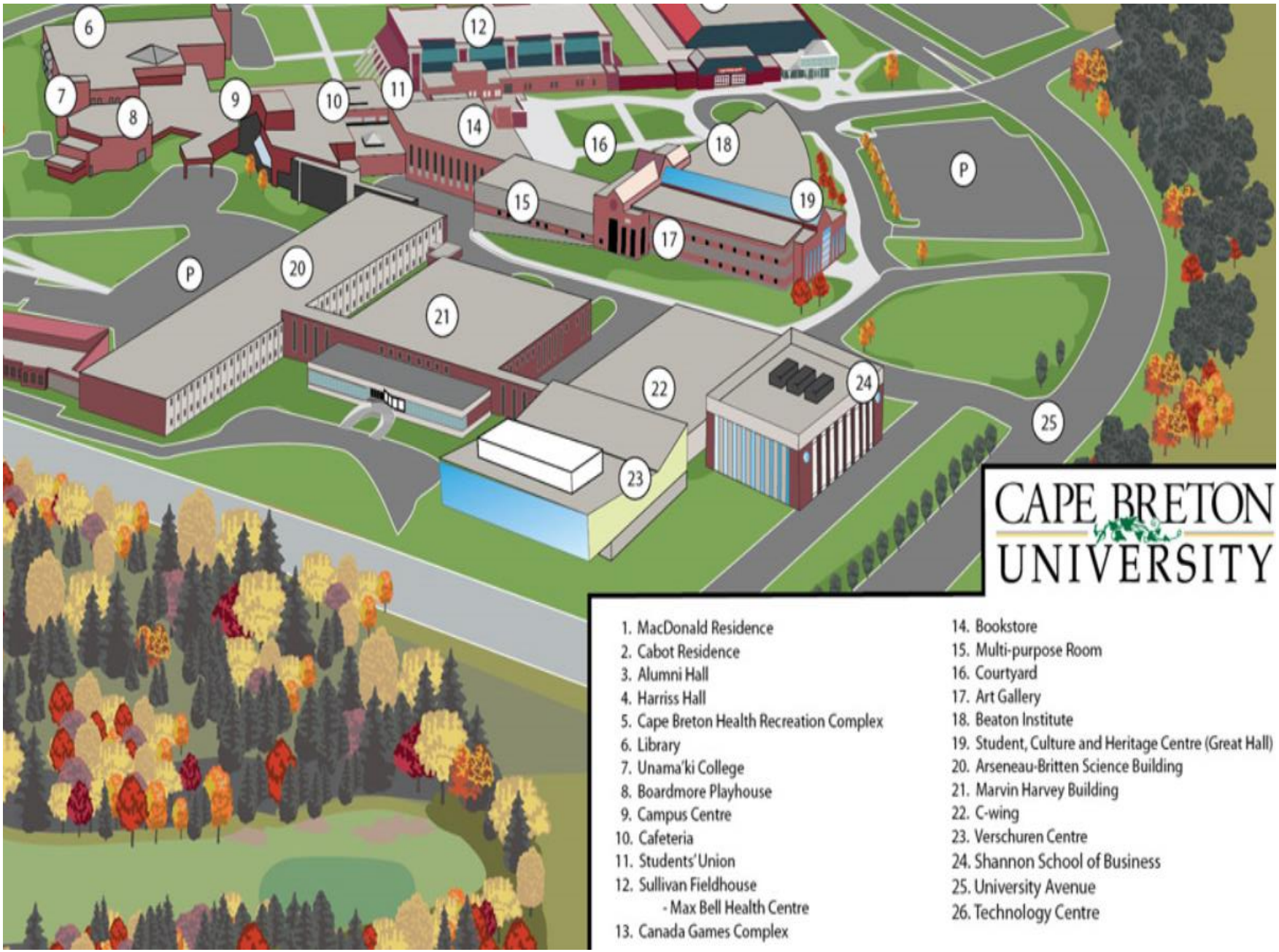
Equations of flow of a fluid with pressure-dependent viscosity through a porous medium of variable permeability are solved in a configuration involving an inclined plane. Analytic solutions are obtained for various forms of viscosity as a function of pressure in order to illustrate the effects of the inclination angle on the flow characteristics and to determine the forms of variable permeability function.

**Riabouchinsky Flow of a Pressure-Dependent Viscosity Fluid in Porous Media** - S.O. Alharbi, University of New Brunswick, Saint John,

Two-dimensional flow of a fluid with pressure-dependent viscosity through a variable permeability porous structure is considered and exact solutions are obtained for a Riabouchinsky type flow. Viscosity is considered proportional to fluid pressure due to the importance and uniqueness of validity of this type of relation in the study of Poiseuille flow, and the effects of changing the proportionality constant on the pressure distribution. Since a variable permeability introduces an additional variable in the flow equations and renders the governing equations under-determined, the current work devises a methodology to determine the permeability function through satisfaction of a condition derived from the specified streamfunction. Illustrative examples are used to demonstrate how the variable permeability and the arising parameters are determined. Although the current work considers flow in an infinite domain and does not handle a particular boundary value problem, it initiates the study of flow of fluids with pressure-dependent viscosity through variable-permeability media and sets the stage for future work in stability analysis of this type of flow.

**Compressed sensing-based CT image reconstruction and its implementation using PDE methods** - Heping Xu, Dalhousie University and George Chen, Cape Breton University

The talk gives a brief introduction of physical and mathematical principles of the Computed Tomography (CT). The compressed sensing formalism and its implementation methods applied to CT image reconstruction are introduced. A variational method in CT reconstruction is investigated.




1. MacDonald Residence
2. Cabot Residence
3. Alumni Hall
4. Harriss Hall
5. Cape Breton Health Recreation Complex
6. Library
7. Unama'ki College
8. Boardmore Playhouse
9. Campus Centre
10. Cafeteria
11. Students' Union
12. Sullivan Fieldhouse
    - Max Bell Health Centre
13. Canada Games Complex
14. Bookstore
15. Multi-purpose Room
16. Courtyard
17. Art Gallery
18. Beaton Institute
19. Student, Culture and Heritage Centre (Great Hall)
20. Arseneau-Britten Science Building
21. Marvin Harvey Building
22. C-wing
23. Verschuren Centre
24. Shannon School of Business
25. University Avenue
26. Technology Centre