February 2012

UNIVERSITY OF JOHANNESBURG

Faculty of Science NEWSLETTER

with focus on Mathematics

Mathematics can be defined as the study of, inter alia, the mathematical concepts of figures and numbers. In mathematics one studies the interdependent relations between concepts, the application of mathematical theories and the abstraction of concepts and theories.

The Department of Mathematics is one of the largest departments in the Faculty of Science. Lecturers in the Department teach on all four campuses of the University. The Department has 42 lecturers (21 permanent; 21 part-time) and 49 tutors, who serve a total of 11027 students in 79 modules. The Department caters for the mathematical needs from any field including science, engineering, finance, economics, health, information technology, to name a few. A full complement of postgraduate qualifications in pure mathematics, including BSc Honours, MSc, and PhD degrees are offered.

Academics within the Department, several of which are NRF rated, are active in the research specialization areas of (mainly) functional analysis, graph theory, and mathematical logic. Ongoing research collaboration links with various other institutions, both locally and abroad, are maintained.

The Department actively engages the communities around UJ regarding initiatives that include fund-raising concerts for local children's homes and the collection of food donations for underprivileged students. In collaboration with the South African Mathematics Foundation the Department also runs a mathematics olympiad training programme for gifted primary and secondary school learners.

The two departmental secretaries, Ms Ria Uys on APK and Ms Martie Wallace on DFC, provide administrative support to staff and students in the Department.

RESEARCH IN THE DEPARTMENT

The research focus areas in the Department

MATHEMATICAL LOGIC RESEARCH GROUP

Dr Willem Conradie, Wilmari Morton, Claudette Robinson

Dr Willem Conradie

Wilmari Morton

The main research focus is on non-classical logics, especially modal logic. Modal logic is an exciting and quickly developing subarea of mathematical logic. It augments classical logic with the ability to qualify the truth of statements, allowing one to express the fact that a statement is possibly true, or necessarily true. The name modal logic comes from the fact that possibly and necessarily are modalities of truth. Many other naturally occurring modalities including obligation and permission, past and future, knowledge and uncertainty, have inspired theoretical developments in modal logic. Today these logics and their mathematical theory are extensively applied in areas as diverse as artificial intelligence, formal specification and verification of computer hardware and software, linguistics, formal philosophy, and mathematics itself, to mention only a few.

Current research includes studies in correspondence and canonicty, finite embeddability properties, and algebraic semantics for hybrid logics.

The group is involved in ongoing collaborative research with colleagues in Denmark, the Netherlands, and Spain.

GRAPH THEORY

Prof Betsie Jonck and Prof Michael Henning, Dr Ernst Joubert, Dr Michael Dorfling, and Yolande Jacobs

In mathematics and computer science, graph theory is the study of graphs, i.e. mathematical structures used to model pairwise relations between objects from a certain collection. A graph G is a finite nonempty set of objects, called vertices, together with a (possibly empty) set of unordered pairs of distinct vertices of G called edges. The basic concepts of graph theory are extraordinarily simple but can be used to express problems from many different subjects. Graph theory can be used in the planning of such prosaic systems as traffic-light networks, mail delivery, and rubbish collection routes. It is used in town planning to find the best locations for service or emergency facilities. For example, the American city, Columbia (Maryland), was completely planned by graph theory. Electronic chips pose interesting challenges because they have nodes (vertices) with wires joining them (edges), and the wires must not cross except at the nodes. Where this is unavoidable, another layer becomes necessary and graph theory can be used to minimise the number of layers.

Although graph theory only came into existence during the first half of the 18th century, during recent decades the subject has exploded and has developed into a major area of mathematics partly due to its status as that branch of pure mathematics which is closest to computer science. However it is the beauty of graph theory that has attracted so many mathematicians to it.

The importance of developing a new generation of problem solvers in the South African context is second to none and cannot be over emphasized. Graph theory, more than any other branch of mathematics feeds on problems. In contrast to most traditional branches of mathematics, an unsolved or open problem in graph theory is often easy to state, but may still take years to solve without any guarantee of a solution. For example, the Four-Colour Problem states that every planar map of connected countries can be coloured using four colours in such a way that countries with a common boundary (not just a point) receive different colours. It is amazing that such a simply stated result resisted proof for one and a quarter centuries, and even today it is not fully understood. The problem dates back to 1852 and in 1976, Appel and Haken announced that they had verified the Four-Colour Problem. However, 1200 hours of computer time were required to perform extensive computations on a part of their proof and cannot be checked by humans.

Prof Betsie Jonck

Prof Michael Henning, A rated researcher.

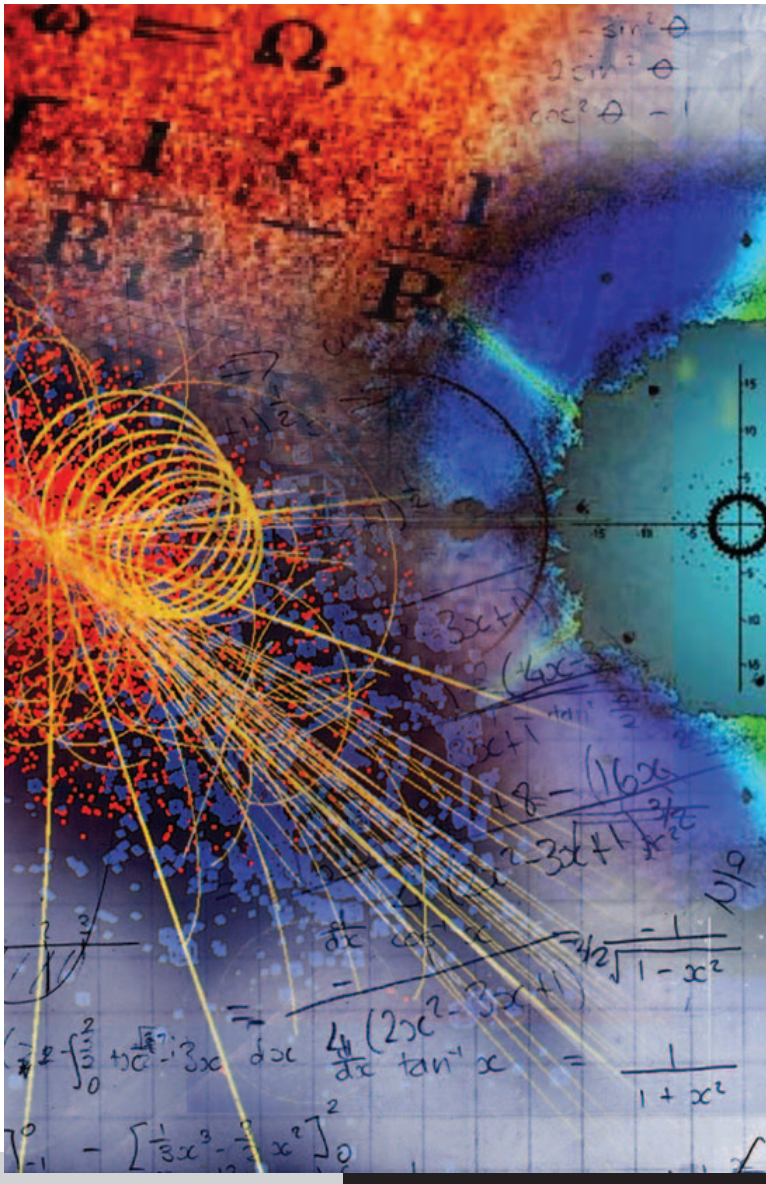
Dr Ernst Joubert

Dr Michael Dorfling

Yolande Jacobs

The University of Johannesburg has an established footprint in graph theory developed over four decades. UJ, and one of its predecessors the Rand Afrikaans University, developed a research niche in the area of graph theory in particular through the scholarship of Prof Izak Broere, known as the Father of graph theory in South Africa, in the 1970s. Several world leaders in graph theory were nurtured at UJ and its predecessor including Prof Christina Mynhardt, the first woman NRF A-rated researcher, who obtained her PhD in graph theory under the supervision of Prof Broere in 1979 and now based in Canada. Other notable graph theorists who have emerged from this institution include Prof Marietjie Frick and Prof Johan Hattingh. Since its inception at UJ in the mid-1970s, the Graph Theory Group continues to grow vigorously. It currently includes five Faculty members (Prof Betsie Jonck and Prof Michael Henning, Dr Ernst Joubert and Dr Michael Dorfling and Ms Yolande Jacobs) as well as several doctoral and postdoctoral students.

"As long as a branch of science offers an abundance of problems, so long is it alive", said David Hilbert in his address to the International Congress of Mathematicians in Paris in 1990. Judged by this criterion, graph theory could hardly be more alive.



FUNCTIONAL ANALYSIS

Dr Gareth Braatvedt, Dr Rudi Brits and Prof Heinrich Raubenheimer

The main focus of research is in abstract spectral theory which could, in a broad sense, be considered as a generalization of the theory of eigenvalues. With the advent and development of the new quantum mechanics in the 1920's, it became increasingly obvious that the mathematical concept of spectrum corresponds closely to a notion already familiar in physics. As such, contemporary research in spectral theory draws ideas from both these fields. Research in the Department specializes in the more abstract setting, where the latest techniques are employed to obtain results connecting the algebraic and spectral structure of elements in the particular space. Recently, some issues related to spectral instability (spectral discontinuity) has also been addressed. In a somewhat different vein, research is also being conducted on connections between abstract spectral theory and the theory of generalized inversion, the latter of which has important applications in the field of mathematical statistics.

Dr Gareth Braatvedt

Dr Rudi Brits

Prof Heinrich Raubenheimer

NUMERICAL RELATIVITY, NUMERICAL ANALYSIS AND SOLUTION OF PDEs

Dr Melusi Khumalo

Numerical relativity

Led by Prof Nigel Bishop of Rhodes University, this collaboration aims to come up with new and better methods in the solution of many problems in numerical relativity. Of particular interest are implicit, semi-implicit and hybrid methods which possess better stability properties than the traditionally used explicit Runge-Kutta schemes.

Collaborators: NT Bishop (Rhodes), D Pollney (Universitat de les Illes Balears, Spain), M Khumalo (UJ) and D Ndzinisa (UJ MSc student)

Numerical analysis – blow up solutions

In this collaboration, the focus is on the numerical solution of integral and integro-differential equations, as well as reaction-diffusion equations. Of interest are problems whose solutions blow up in finite time.

Collaborators: H Brunner (Memorial University & Hong Kong Baptist University), M Khumalo (UJ) and PG Dlamini (UJ MSc student)

Solution of PDEs using the successive linearization approach

In this work, the aim is to solve PDEs using an exciting new method, the successive linearization method (SLM). The method has been shown to be highly efficient in ODEs.

Collaborators: SS Motsa (UKZN), M Khumalo (UJ) and SP Zikalala (UJ MSc student)

Dr Melusi Khumalo

OTHER RESEARCH AREAS

Ruan Moolman is doing research in the field of metacognitive skills in enhancing critical thinking of second year mathematics students. In particular, possible differences in above skills, between extended/augmented degree and main stream degree students. This is done in collaboration with Professor Margot Berger, at the Marang Centre for Science and Mathematics Education, at the University of the Witwatersrand. He currently started new research interest in the field of study groups, in collaboration with Prof W Clarke, Department of Electrical Engineering, University of Johannesburg. He is also working on the possible curriculum changes within the Faculties of Engineering & the Built Environment mathematics courses, as part of an in response to the Engineering Council of South Africa (ECSA) 2011 Audit of UJ.

A RATED RESEARCHER IN MATHEMATICS

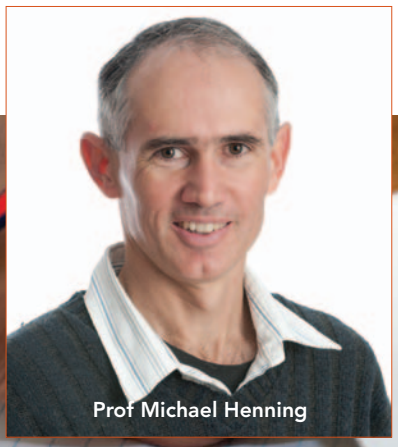
Prof Michael Henning

Since its inception at UJ in the mid-1970s, the Graph Theory Group continues to grow vigorously. On 1 May 2010, UJ intensified efforts to strengthen the Graph Theory Group by appointing Prof Michael Henning as a Research Professor.

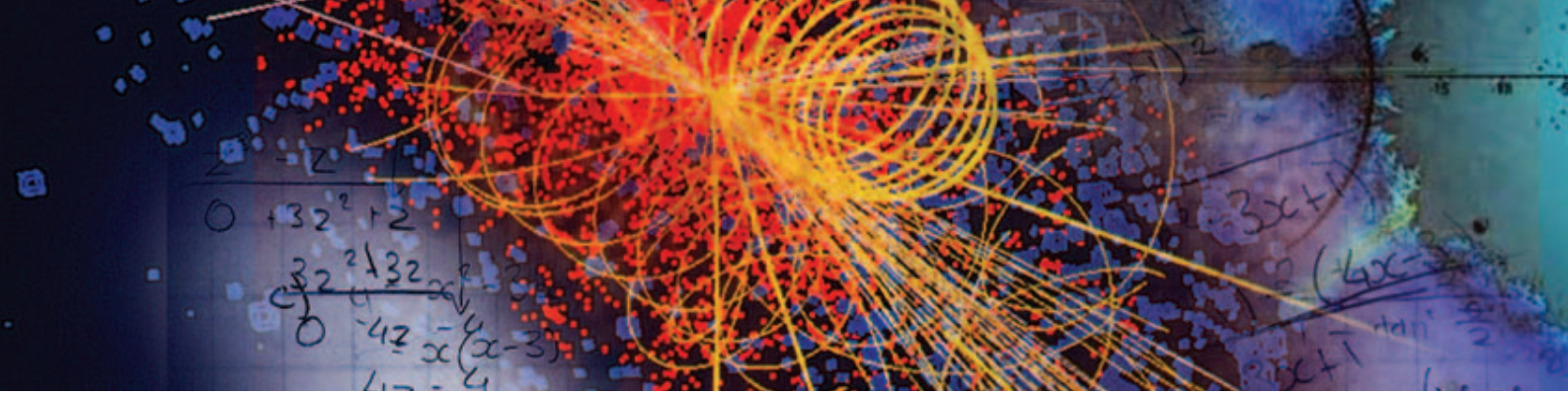
In January 1989, Prof Henning started his academic career as a lecturer at the University of Zululand, before accepting a lectureship in mathematics at the former University of Natal in January 1991. In January 2000 he was appointed a Full Professor at the University of Natal, which later merged with the University of Durban-Westville to form the University of KwaZulu-Natal. After spending almost 20 years at the University of KwaZulu-Natal and one of its predecessors, the University of Natal, he moved to UJ to join the Graph Theory Group.

In 1996, Prof Henning was awarded the President's Award by the then Foundation for Research Development and the Vice-Chancellor's Award by the University of Natal. In 2000, he received the Hall Medal from the Institute of Combinatorics and its Applications based in Canada. The Hall Medal recognizes outstanding research achievements by members of the Institute of Combinatorics and its Applications who are not over age 40. Only two such medals were awarded in 2000, the other recipient being an Australian. In 2000, Prof Henning became a National Research Foundation B1-rated scientist, a rating which he was re-awarded in 2004. In 2005 he received the Award for Research Distinction from the South African Mathematical Society. Only one such award is presented each year. In 2009, he improved his NRF rating to an A2-rating which he holds until December 2014.

Prof Henning is regarded as a world leader in domination theory in graphs. He serves on the editorial board of four international mathematics journals, having recently been appointed as co-managing editor of the prestigious Japan-based Graphs and Combinatorics. To date he has 283 publications in international mathematics journals with a further 12 papers accepted for publication but not yet appeared and an additional 25 papers submitted for publication and in the refereeing process. He currently has four PhD students under his supervision as well as one postdoctoral student from Germany. His current research is on the interplay between total domination in graphs and transversals in hypergraphs. He also uses transversals in hypergraphs to obtain important results in various areas of hypergraphs, such a colouring, matching, domination and independence. Prof Henning has been a principal speaker at several conferences in various countries, including Germany, France, Poland, the Slovak Republic, and the USA. He collaborates extensively with many co-authors from several countries, including Canada, China, Denmark, England, France, Germany, Iran, Israel, Poland and Spain. His main collaborators are Professor Wayne Goddard from Clemson University in the USA, Professor Teresa Haynes from East Tennessee State University in the USA, Professor Dieter Rautenbach from the University of Ulm in Germany, and Dr Anders Yeo from Royal Holloway, University of London, in England.



Prof Michael Henning



RESEARCH VISITS CONFERENCES AND PAPERS

In July 2011 **Dr Melusi Khumalo** visited the Memorial University of Newfoundland on invitation of Prof Hermann Brunner. During the visit, the framework for further research collaboration was discussed and they started putting together a joint research paper. Papers were presented at the South African Gravity Society (SAGS) conference, held in Grahamstown in September as well as the joint American and South African Mathematical Societies Congress in Port Elizabeth in November. He continues to visit Prof Bishop at Rhodes University on a regular basis as part of the collaboration.

Two papers of Dr Khumalo have been published or accepted for publication in accredited international journals during 2011:

Khumalo, M. Transformation of local bifurcations under collocation methods. J Korean Math Soc. 48 (2011), 1101 – 1123;

Dlamini, PG, Khumalo, M. On the computation of blow-up solutions for semilinear ODEs and parabolic PDEs. To appear (accepted): Math Probl Eng.

MATLAB SHORT COURSE, NOV 2011

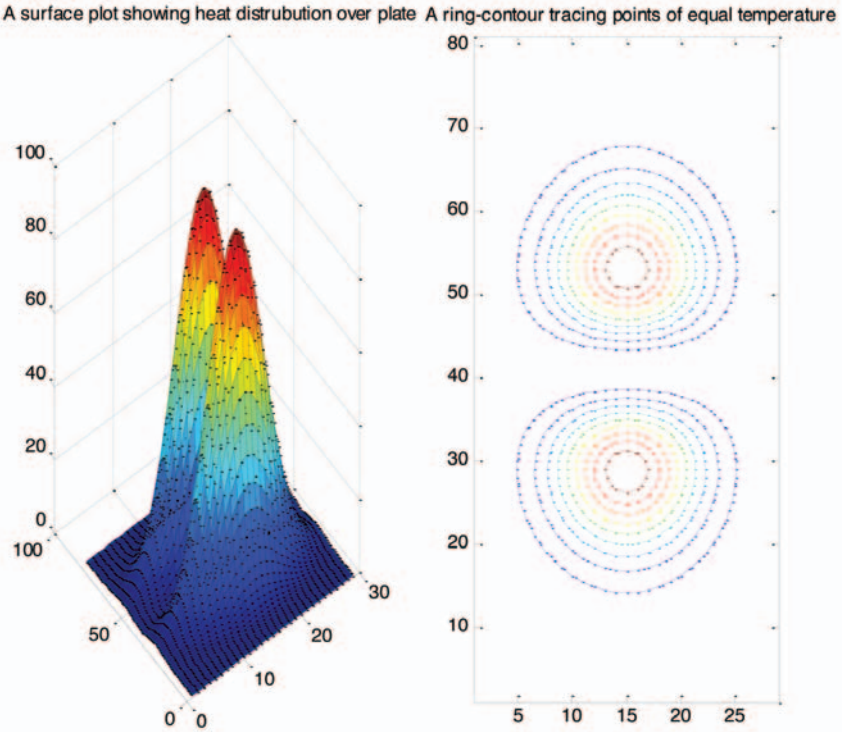
A three day introduction to the MATLAB software was offered by **Ms Hanti Kotze**, senior lecturer in mathematics on Doornfonteinn Campus to the lecturers of the Department of Mechanical Engineering on the same campus.

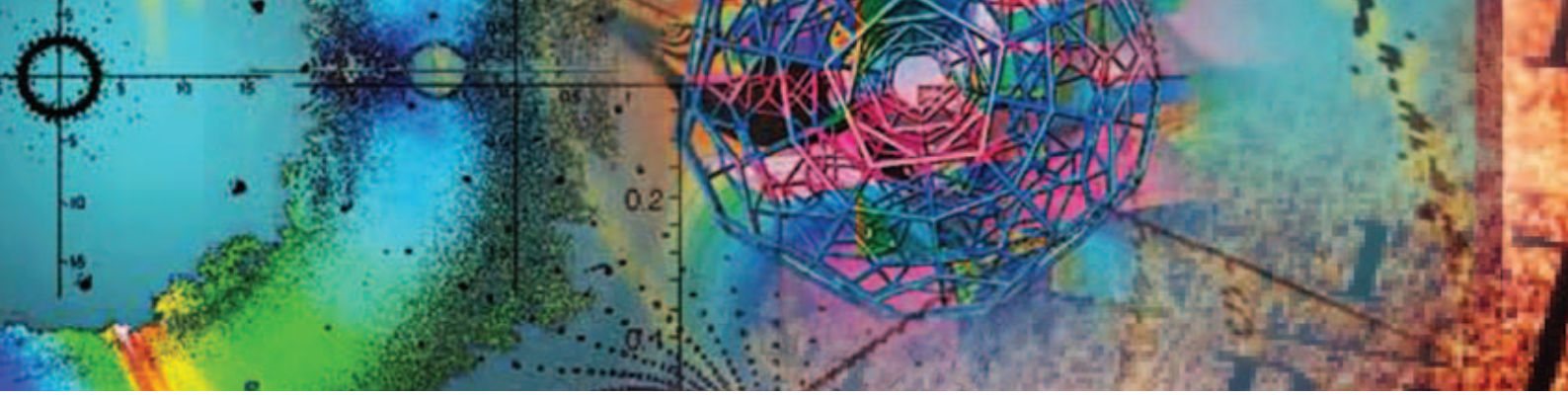
In August, Ms Kotze was commissioned by the outgoing Head of the Department of Mechanical Engineering, Mr Peter Stachelhaus, to draft a workshop suitable for his staff, most of which are currently involved in masters or doctoral studies, and with a need to be equipped with basic programming skills. In selecting her topics, Ms Kotze focused on mechanical applications such as harmonic oscillators, damped and/or free spring-mass systems with two degrees of freedom and non-linear attractors.

Fifteen mechanical lecturers attended the workshop over three days. The contents included:

- Modelling with matrices – a fundamental building stone on which MATLAB operates
- Graphical visualization in 2-D, 3-D and polar plane as well as contour and surface plots
- Iterations and the structuring of loops
- Curve fitting and the interpolation of discrete data as a polynomial curve
- Modelling with ordinary differential equations, the use of function files and graphical interpretation of phase portraits

As MATLAB is the preferred choice of engineers world-wide, Ms Kotze is committed to continuously liaise with her ex-students and colleagues, sharing her expertise and being enthusiastic about the engineering applications her subject endorses.





HIGHLIGHTS IN THE DEPARTMENT

AWARDS IN THE DEPARTMENT

Vice Chancellor's Distinguished Awards

In 2008 the Vice-Chancellor established a series of awards aimed at promoting core academic, service and support functions through awarding significant prizes across a series of categories.

The categories are:

- Outstanding Researcher of the Year
- Most Promising Young Researcher of the Year
- Teacher Excellence
- Innovator of the Year
- Service beyond the normal Call of Duty

Numerous lecturers in the Department of Mathematics were recipients of this prestigious award.

2011

Dr Ernst Joubert: Most promising young researcher of the year

2010

Ruan Moolman: Teacher excellence

Mr Moolman has shown a passionate dedication to the teaching of mathematics, a subject he has taught at the University of Johannesburg for the last six years. He has proved to be a dedicated teacher and professional mathematician who will do all that is required, and more, to ensure the success of his students. Mr Moolman makes extensive use of the internet and Edulink in presenting and augmenting the content of his teaching.

2008

Dr Willem Conradie: Most promising researcher of the year

Faculty of Science Teaching Award

At the Faculty of Science Award ceremony in 2011 an Award for Excellence was introduced. The first recipient of the 2011 Award was **Mrs Hanti Kotze**. Her portfolio addresses the many facets of her teaching and learning philosophy, where it is evident that her work ethics clearly expresses her yearning to pass on her attained knowledge and expertise to students and colleagues alike. It is apparent that she sets an example in living a life that shows her commitment in every aspect of her teaching. A concrete way in which she addresses the cumulative nature of her subject is to set weekly targets by forcing the students to work continuously. She custom designs Edulink assignments (firstly created in Respondus) based on the preceding week's content and publish these at least 5 days prior to the due date on Edulink. This eLearning assessment style proved effective in the Mathematics 4 module where the majority of the students are working full time and often have to be on an engineering site locally or abroad. Certainly one of the prime teaching innovations in the Department of Mathematics over the last decade was Ms Kotze's vision to implement a computer technology component whereby the engineering student could be exposed to essential programming principles imperative to all present age scientists and engineers; it is imperative that vocationally orientated programmes needs to be continuously streamlined with industry and the needs in the workplace. A modus operandi of how she single-handedly undertook the enterprise to modernise the offering of Mathematics 3 and later-on also Mathematics 4 through a mathematical modelling approach, demonstrates the restructuring of the syllabus, researching several software options, getting familiar with the selected MATLAB software and compiling new study material in the form of a textbook.

Hanti Kotze.

COMMUNITY PROJECTS

The Department was involved with three community projects in 2010.

• The St Lawrence Children's Home Project:

Two musical concerts were held to raise funds for the St Lawrence Children Home. Talented lecturers and students in the Department played instruments and performed musical pieces in this fundraising concerts. The musical concerts fund raising continued in 2011.

Additional to above mentioned, mathematics was taught at home by a few of the lecturers, free of charge, to these children.

• UJ MAPS Outreach to Schools Programme

A UJ MAPS (Math's Advancement Program) Outreach to Schools Programme was initiated to assistant learners. This programme has expanded greatly since it was founded by Mr Gavin Robinson and is now part of the Science Centre's initiatives. The UJ MAPS Outreach to Schools Programme has received the silver award in 2009 and in 2010 the gold award for the top community engagement project at UJ.

• Mathematics Olympiad Training Programme

The Department of Mathematics in collaboration with The South African Mathematical Foundation (SAMF) has started a Mathematics Olympiad Training Programme. This programme is aimed at promoting mathematics comprehension at school level in an interactive and informal environment. The programme focuses on training for grade 7-9 (junior) and grade10-12 (senior) learners for the annual Harmony Mathematics Olympiad. This programme is free of charge and funding is available for learners from disadvantaged communities in the form of a travel allowance.

SHORT LEARNING PROGRAMMES

• Alternative Semester Mathematics

Eleven short learning programmes were implemented for the first time in 2010. In the past, when a student failed one of his mathematics modules, he/she had to redo the course the following year either in the main stream or in a limited contact stream. Last year the limited contact programmes were cancelled and the ASMA courses (Alternative Semester Mathematics) were introduced. These courses are presented in the immediate consecutive semester following the main stream presentation.

• Mathematics for Diploma students

The Mathematics for Diploma students (MFD) was introduced to teach students currently studying a national diploma in the Faculty of Economic and Financial Sciences (FEFS). The basic mathematical knowledge that is required to enrol for a degree programme in FEFS is taught. Mr Ronnie Maartens is coordinating these service courses for FEFS.

MATERIAL DEVELOPMENT

Ms Rika Cronje and Mr Titus Mohubedu are to develop videos in English and Sepedi on Mathematics 1A, 1B, 1C 1D content for students to view in their own time. The project will also be extended to the calculus course of the second year and therefore add value by working through all the extra examples discussed in the videos.

Jaco Bruyns, recently appointed as Deputy Chairman in the Department of Mathematics.

Prof Betsie Jonck, HOD

Contact the Department of Mathematics on 011 559 2848

www.uj.ac.za