



ANNUAL REPORT Faculty of Engineering

2018

Fakulteit Ingenieurswese
JAARVERSLAG



UNIVERSITEIT
iYUNIVESITHI
STELLENBOSCH
UNIVERSITY

100
1918 · 2018



ENGINEERING
EZOBUNJINELI
INGENIEURSWESE

Contents

2 Faculty of Engineering

Overview | Oorsig
Faculty Management

7 Civil Engineering

Highlights
Focus: 3D Printing of Concrete
Research Themes
Contacts

15 Electrical and Electronic Engineering

Highlights
Focus: The Magnetic Gear – an attractive, innovative technology
Research Themes
Contacts

23 Industrial Engineering

Highlights
Focus: Helping computers to analyse opinions and leveraging sentiment analysis in decision making
Research Themes
Contacts

31 Mechanical and Mechatronic Engineering

Highlights
Focus: Digital Twins for the South African Industry 4.0
Research Themes
Contacts

39 Process Engineering

Highlights
Focus: “Awesome” seaweeds researched in ambitious, collaborative project
Research Themes
Contacts

46 Outreach Programmes



Janke van Dyk (top matriculant in 2017) with Prof Steven Bradshaw (left) and August Engelbrecht.

For three-quarters of a century now, the Faculty of Engineering has been upholding a proud record of contributing to the country's economy through the training of world-class engineering graduates.

Maintaining our momentum of excellence

An accreditation team from the Engineering Council of South Africa (ECSA) visited the Faculty in September 2018. The outcome of the visit is that our six programmes have again been accredited by that body. The team was full of praise for the quality of our teaching, the range of our facilities and the positive experiences attested to by our undergraduate students.

The Faculty's highly structured programmes continue to draw some of the best matriculants year on year. About 10% of our nearly 800 first-year students attained an average of more than 90% in matric. This year, the Faculty could boast that 2017's top matriculant in the country, Janke van Dyk, selected Stellenbosch at which to study Chemical Engineering in 2018.

Not only do we draw top students, Engineering is privileged to have attracted an eminent academic. Prof Andries Engelbrecht, an A-rated NRF researcher in Computer Science, will hold the Voigt Chair in Data Science in the Department of Industrial Engineering from 1 January 2019.

Our expertise and excellence enjoyed further recognition in 2018 when the Faculty was awarded a

Department of Science and Technology/NRF South African Research Chair in Sugarcane Biorefining. Prof Johann Görgens, Head of the Bioresource Engineering Group in the Department of Process Engineering, holds this Chair.

The Faculty is also strengthening its standing on the African continent. As an active participant in the African Research Universities Alliance (ARUA), Stellenbosch University was designated to host the ARUA Centre of Excellence in Energy. The Energy Centre is multidisciplinary and comprises a network of 15 universities that focus on the nexus of energy, water and food through applied research to ensure sustainable agricultural development in Africa. Two of the Faculty's acclaimed researchers in the field of energy, Profs Sampson Mamphweli and Johann Görgens, serve as the directors of the new ARUA Centre of Excellence in Energy.

Our world-class research facilities expanded further this year with a large fan and cooling system test facility, one of a kind in the world, officially opened at the Engineering complex in November. This exceptional facility was erected as part of the University's participation in the European-funded Horizon2020 MinWaterCSP Project.

Broadening our access

To promote Engineering as a profession and to alleviate the shortage of engineers in the country, the Faculty has been driving targeted undergraduate student recruitment throughout South Africa and Namibia for more than 15 years. The dual aim of the drive is to attract the best students and to promote diversity. The targeted group includes students for whom Stellenbosch previously would not have been their university of choice. A special event, *The First Generation Experience*, was held for top learners whose parent did not study at a tertiary institution and who therefore in this capacity do not have the experience to serve as role-models where higher education is concerned. Much effort is additionally being invested in promoting the engineering profession among women.

Since 2017, the Faculty has been cultivating a stronger relationship with numerous bodies, including the Stellenbosch University Centre for Pedagogy (SUNCEP), the Department of Science and Technology (DST), the South African Agency for Science and Technology Advancement and the Moshul Scholarship Foundation.

Vir 'n driekwart eeu handhaaf die Fakulteit Ingenieurswese nou al 'n trotse rekord deur by te dra tot die land se ekonomie met die opleiding van ingenieursgraduandi van wêreldgehalte.

Behoud van ons momentum van uitnemendheid

'n Akkreditasiespan van ECSA (Ingenieursraad van Suid-Afrika) het die Fakulteit in September 2018 besoek. Die uitkoms van die besoek was dat ons ses programme steeds deur ECSA geakkrediteer is. Die span was vol lof oor die gehalte van ons onderrig, die omvang van ons fasiliteite en die positiewe ervarings waarvan ons voorgraadse studente getuig het.

Die Fakulteit se programme is hoogs gestruktureerd en lok steeds elke jaar van die beste matrikulante. Sowat 10% van ons bykans 800 eerstejaarstudente het 'n gemiddeld van meer as 90% in matriek behaal. Dié jaar kon die Fakulteit spog dat 2017 se topmatrikulant in die land, Janke van Dyk, gekies het om in 2018 Chemiese Ingenieurswese op Stellenbosch te kom studeer.

Nie net trek ons topstudente nie, Ingenieurswese was ook baie bevoorreg om in die afgelope jaar 'n vooraanstaande akademikus te lok. Prof Andries Engelbrecht, 'n A-gegradeerde NNS-navorsers in Rekenaarwetenskap, sal vanaf 1 Januarie 2019 die Voigt-leerstool in Datawetenskap in die Departement Bedryfsingenieurswese beklee.

Ons kundigheid en uitnemendheid het in 2018 verdere erkenning geniet toe 'n DWT/NNS SA Navorsingsleerstool in Suikerriet-bioraffinering aan die Fakulteit Ingenieurswese toegeken is. Prof Johann Görgens, hoof van die Biohulpbron-ingenieurswesegroep in die Departement Prosesingenieurswese, beklee hierdie leerstoel.

Ook op die Afrika-kontinent versterk die Fakulteit sy aansien. As 'n aktiewe deelnemer aan die Alliansie van Afrikanavorsingsuniversiteite (ARUA) is die US aangewys om die ARUA Sentrum van Uitnemendheid in Energie te huisves. Die Energiesentrum is multidisiplinêr en bestaan uit 'n netwerk van 15 universiteite wat aandag wil gee aan die neksus

tussen energie, water en voedsel deur toegepaste navorsing om volhoubare landbou-ontwikkeling in Afrika te verseker. Twee van die Fakulteit se gesiene navorsers op die gebied van energie, proff Sampson Mamphweli en Johann Görgens, dien as die direkteure van die nuwe ARUA Sentrum van Uitnemendheid in Energie.

Ons wêreldklas-navorsingsfasiliteite is dié jaar verder uitgebrei met 'n groot waaier-en-verkoelingstelsel-toetsfasiliteit, die enigste in sy soort ter wêreld, wat amptelik in November by die Ingenieurswese-kompleks geopen is. Hierdie uitsonderlike fasiliteit is opgerig as deel van die Universiteit se deelname aan die Europees-befondsde Horizon2020 MinWaterCSP-projek.

Verbreiding van toegang

Om Ingenieurswese as beroep te bevorder en ook die tekort aan ingenieurs in die land te probeer verlig, doen die Fakulteit al meer as 15 jaar lank gerigte voorgraadse studentewerwing regoor die land en in Namibië. Die tweeledige doel is om die beste studente te trek en terselfdertyd diversiteit te bevorder. Hierdie diverse groep sluit studente in vir wie Stellenbosch nie voorheen 'n voorkeuruniversiteit sou gewees het nie. 'n Spesiale geleentheid, die *Eerstegenerasie-ervaring*, is gehou vir top leerders wie se ouers nie aan 'n tersiêre inrigting studeer het nie en in hierdie hoedanigheid dus nie as rolmodelle vir naskoolse opleiding kan dien nie. Groot moeite word ook gedoen om die ingenieursberoep onder vroue te bevorder.

Die Fakulteit het sedert 2017 nouer bande gesmee met instansies soos SUNCEP (Universiteit Stellenbosch Sentrum vir Pedagogie), die Departement vir Wetenskap en Tegnologie (DWT), die Suid-Afrikaanse Agentskap vir die Bevordering van Wetenskap en Tegnologie, die *Moshul Scholarship Foundation* en vele ander. Dié instansies bedryf programme soos

Researchers and industry partners interact during the Industry Open Day.



These bodies run programmes such as Saturday and holiday schools, where specifically selected top Grade 11 and 12 learners in Mathematics and Physical Sciences are offered additional support in these subjects to prepare them better for school and university studies. A good example of such a programme is the Talent Development Programme funded by DST and administered by SUNCEP, which is run in all nine provinces.

The programmes offered by Engineering are challenging and demanding but the many systems that we have introduced over the years to support students have made a great difference. These include tutoring and mentoring programmes, dean's periods, revision lectures and group learning sessions for first years and the appointment of two part-time educational psychologists. In the dean's division, one staff member focuses exclusively on the task of student support and the other on the task of student recruitment and student retention.

Promoting our impact on communities

Most of our research projects are driven by and are applicable to real-life engineering problems in our communities. We believe that our research makes a strong, positive impact on the community at large and that it improves the standard of living and quality of life of people. The Faculty is exceptionally successful in solving engineering problems in collaboration with the industry, from which it receives great support and recognition.

An example of such support is the significant funding that has been received for two research projects currently being conducted. One of these is the five-year project funded by the Intelligence Advanced Research Projects Activity (IARPA) in the USA and of which Prof Coenrad Fourie is co-Principal Investigator. This project, which deals with superconducting

integrated circuits, amounts to over R30 million and funds one postdoctoral fellow, three engineers, three doctoral candidates and six master's degree students. The other project is the development of Africa's very first postgraduate programme in Fire Engineering in the Faculty's Fire Engineering Research Unit – FireSUN – which will provide the necessary expertise to help protect all communities in Africa against fire. This project received a financial injection of R2,9 million from the Lloyd's Register Foundation.

To strengthen and expand relationships and networks with the industry, the Faculty held its first Industry Open Day in collaboration with the Faculty of Science at the end of November. Researchers displayed posters of their most recent research and discussed these with the industry delegates who attended this very successful day. It was an ideal opportunity for industry partners and researchers to talk with a view to possible collaboration. The Faculty's latest publication, *Research Finder*, was launched at the event. This publication contains useful information on our research projects and the contact details of the researchers involved.

The Faculty's Advisory Board was reconstituted in 2018, with prominent national and international heavyweights from academia and from the industry serving on the Board.

Sustainability

An exciting investment over the next seven to eight years is the R720 million that is to be spent on the renovation of the Engineering complex. The Department of Industrial Engineering is already boasting its own building for the first time after moving into the former Information Technology building in 2018 following extensive renovation. Next in line is the Mechanical and Mechatronic Engineering building, with the buildings for Process Engineering, Civil Engineering and Electrical and Electronic Engineering following after that. In 2019, a brand-new Pavement Laboratory will also be erected.

The future

The Faculty celebrates its 75th year of existence in 2019. With the best of students, lecturers, support staff and renovated and modern facilities, the Faculty of Engineering looks forward to continuing to deliver the best of engineers for the country.

Our student recruiter, August Engelbrecht, and the enthusiastic top learners who attended the First Generation Experience.



Saterdag- en vakansieskole waar spesifiek gekeurde Graad 11- en 12-toeleerders in Wiskunde en Fisiese Wetenskappe addisionele ondersteuning in die vakke ontvang om hulle beter voor te berei vir skool- en universiteitstudie. Een goeie voorbeeld hiervan is die *Talent Development Programme* wat deur die DWT befonds en deur SUNCEP geadminestreer word. Die program vind in al nege provinsies plaas.

Ingenieurswese se programme is uitdagend en veeleisend. Die vele ondersteuningstelsels wat ons oor die jare daargestel het om studente te ondersteun, het 'n groot verskil gemaak. Dit sluit onder andere tutor- en mentorprogramme, dekaansperiodes, hersieningslesings en groepleersessies vir eerstejaars sowel as die aanstelling van twee deeltydse opvoedkundige sielkundiges in. In die dekaansafdeling hanteer een personeelid die taak van studenteondersteuning en 'n ander een se aandag is uitsluitlik op studentewerwing en studenteretensie gerig.

Bevordering van ons impak op die samelewing

Die meeste van ons navorsingsprojekte word gedryf deur en is van toepassing op werklike ingenieursprobleme in die gemeenskap. Ons glo dat ons navorsing inderdaad 'n groot positiewe impak op die breër samelewing het en mense se lewensgehalte en -standaard verbeter. Die Fakulteit is uiters geslaagd om bedryfsprobleme saam met die industrie op te los en geniet groot ondersteuning van en erkenning deur die industrie.

Voorbeelde van bogenoemde ondersteuning is beduidende befondsing wat vir twee verskillende navorsingsprojekte ontvang is. Prof Coenrad Fourie is tans mede-hoofondersoeker op 'n vyfjaar-projek wat deur IARPA (*Intelligence Advanced Research Projects Activity*) in die VSA befonds word. Die projek op die gebied van geïntegreerde supergeleierbane beloop oor die R30 miljoen en befonds tans een na-doktorale genoot, drie ingenieurs, drie doktorale en ses meestersgraadstudente. Die Fakulteit se Eenheid vir Brandingenieurswesenvorsing (FireSUN) het 'n finansiële inspuiting van R2,9 miljoen ontvang van die *Lloyd's Register Foundation*. Dit sal gebruik word om Afrika se heel eerste nagraadse program in brandingenieurswese te ontwikkel, wat die nodige kundigheid sal voorsien om alle gemeenskappe in Afrika teen brande te help beskerm.

Om verhoudinge en netwerke met die industrie te verstewig en uit te brei, het die Fakulteit einde November sy eerste Industrie-opedag in samewerking

met die Fakulteit Natuurwetenskappe aangebied. Navorsers het plakkate van hul jongste navorsing uitgestal en gesprek gevoer met die afgevaardigdes wat die geslaagde dag bygewoon het. Dit was 'n ideale geleentheid vir industrievrennote en navorsers om te gesels met die oog op moontlike samewerking. Tydens die geleentheid is die Fakulteit se jongste glanspublikasie (*Research Finder*) bekendgestel. Dit bevat nuttige inligting oor ons navorsingsprojekte asook die kontakbesonderhede van die betrokke navorsers.

Die Adviesraad van die Fakulteit is in 2018 hersaamgestel met 'n paar prominente nasionale en internasionale swaargewigte uit die akademie en industrie wat daarin dien.

Volhoubaarheid

'n Opwindende belegging in die volgende sewe tot agt jaar is die R720 miljoen wat bestee gaan word vir die opknapping van die Ingenieurswese-gebouekompleks. Die Departement Bedryfsingenieurswese spog nou vir die eerste maal met hul eie gebou nadat hulle in 2018 die ou Informasietegnologiegebou betrek het ná omvattende verbeterings. Volgende aan die beurt is die Meganiese en Megatroniese Ingenieursgebou, met die geboue van Prosesingenieurswese, Siviele Ingenieurswese en Elektriese en Elektroniese Ingenieurswese wat daarop sal volg. In 2019 sal 'n splinternuwe Plaveisel laboratorium ook opgerig word.

Vooruitsig

Die Fakulteit vier in 2019 sy 75ste bestaansjaar. Met goeie studente, dosente, ondersteuningspersoneel, asook opgeknapte en moderne fasiliteite sien die Fakulteit Ingenieurswese daarna uit om steeds goeie ingenieurs aan Suid-Afrika te lewer.



Prof Wikus van Niekerk
Dean: Engineering.
Dekaan: Ingenieurswese.

Faculty Management



DEAN

Prof Wikus van Niekerk
engdean@sun.ac.za

VICE-DEAN: Research and Industry Liaison

Prof Petrie Meyer
pmeyer@sun.ac.za



VICE-DEAN: Teaching and Quality Assurance

Prof Anton Basson
ahb@sun.ac.za



Department of Civil Engineering

CHAIR: Prof Jan Wium
janw@sun.ac.za



Centre for Civil Engineering

DIRECTOR: Prof Jan Wium
janw@sun.ac.za

Department of Electrical and Electronic Engineering

CHAIR: Prof Herman Engelbrecht
hebrechtr@sun.ac.za



Centre for Electrical and Electronic Engineering

DIRECTOR: Prof Johan du Preez
dupreez@sun.ac.za



Department of Industrial Engineering

CHAIR: Prof Corne Schutte
corne@sun.ac.za



Institute for Industrial Engineering

DIRECTOR: Mr Konrad von Leipzig
kvl@sun.ac.za



Department of Mechanical and Mechatronic Engineering

CHAIR: Prof Kristiaan Schreve
kschreve@sun.ac.za



Institute for Thermodynamics and Mechanics

DIRECTOR: Prof Prof Nawaz Mahomed
nawaz@sun.ac.za



Department of Process Engineering

CHAIR: Prof André Burger
ajburger@sun.ac.za



Centre for Process Engineering

DIRECTOR: Prof Johann Görgens
jgorgens@sun.ac.za



Centre for Renewable and Sustainable Energy Studies

DIRECTOR: Prof Sampson Mamphweli
mamphweli@sun.ac.za



Institute for Biomedical Engineering

DIRECTOR: Prof Martin Nieuwoudt
mnieuwoudt@sun.ac.za



Civil Engineering



The New Pavement Laboratory will lay the foundation for a younger generation to carry on with research in the important field of Pavement Engineering for many decades to come.



Participants in the Jac van der Merwe competition for Innovation are from the left: Jody Julies (Mechatronic), Ruan Spies (joint-runner-up, Industrial), Frederick Bester (winner, Civil), Claudia de Wet (Mechanical), Given Ramadzanga (representing the sponsor, MultiChoice), Suzanne van Niekerk (Chemical/Process) and Kobus Kotzé (joint-runner-up, Electrical and Electronic).

Civil Engineering student wins prestigious innovation prize

Frederick Bester, a fourth-year student in 2018, continued the Department's winning streak in the prestigious Jac van der Merwe Competition for Innovation awarded annually to the student with the most innovative final-year project. It is the third consecutive year that a student from this Department wins top honours.

Frederick's final-year project was titled *Benchmark Structures for 3D Printed Concrete*. Prof Gideon van Zijl was his study leader. (Read more about this project on page 10.)

Furthermore, Frederick and Marchant van den Heever combined their projects in 3D printed concrete to present at the annual Growthpoint Greenovate Awards. The Greenovate Awards, hosted in Johannesburg, exposes students to key focus areas concerning sustainability within the industry and introduces industry to the talent developments available to them. Competing against students from eight South African universities Frederick and Marchant achieved third place in the Engineering category. To crown it

all, Frederick has been accepted to present his project at the FIB Symposium for concrete innovations in materials, design and structures, hosted in May 2019 at Kraków, Poland.

R2,9 m grant leads to first-ever postgraduate programme in fire engineering

Stellenbosch University's Fire Engineering Research Unit (FireSUN) has received a financial injection of R2,9 million that will be used to develop Africa's first-ever postgraduate programme in fire engineering – ultimately providing the expertise needed to keep the African continent safe in the case of fire.

The FireSUN unit was established in 2017 and aims to reduce the impact of fire by undertaking research and to build the capacity and expertise of fire and structural engineers. The team, located within the Department of Civil Engineering, is the first university research group focused on fire safety in Africa.

The R2,9 million grant was received from the Lloyd's Register Foundation, a charity with a mandate to protect life and property, support education,

engineering-related research and public engagement. These funds mean the FireSUN team can now expand their work by offering postgraduate degrees (MEng and PhD) in fire safety engineering (FSE) and structural fire engineering (SFE). “This represents an exciting development for fire safety engineering in South Africa, and Africa as a whole,” says Dr Richard Walls, who heads up SU’s FireSUN team.

“Research shows that South Africa has one of the highest fire related death rates per capita worldwide, many of which occur in informal settlements,” says Dr Walls.

“With the growth of the African population and of the local mining, manufacturing and resource processing industries the associated fire risks of the continent are rapidly increasing, along with the need for fire engineering professionals. To this end a master’s in engineering (MEng) and PhD degrees in fire engineering will develop the engineering capacity the continent needs,” he explains.

“As any good fire engineer will tell you – fire engineering is an incredibly broad field with a large variety of specialist topics such as fire dynamics, suppression system design, evacuation, structural fire design, emergency response, detection and much more,” concludes Dr Walls.

New Pavement Laboratory

A New Pavement Laboratory that will support the SANRAL Chair in Pavement Engineering, is currently being constructed at the Department of Civil Engineering. In 2016, the South African National Roads Agency Ltd (SANRAL) provided an endowment of R30 million for the continuation of the Chair in Pavement Engineering, which was established in 2001. This large endowment will sustain the Chair for the next three decades.

Since its inception the Chair has delivered more than 80 postgraduate students in pavement engineering of which 7 are doctoral degrees. The rising student numbers in this field has led to a great need to a larger, more modern laboratory, which can handle

the volume and scope of the research in pavement engineering. The research includes liquefaction of Cape soils, bitumen rheology and the use of recycled concrete and masonry in construction. Research regarding geotechnics will also be carried out in the new laboratory.

Planning and preparation of the laboratory started as far back as 2014. A team of experts were involved and much time and effort was put in to ensure that the laboratory is optimally functional and aesthetically attractive. Three staff members, Prof Kim Jenkins,

Dr Chantal Rudman and Riaan Briedenhann, worked closely with the design team, making good use of their expertise and knowledge. Between the three of them they designed the vibration slab fill, which from a structural viewpoint is complex and expensive.

Prof Fred Hugo placed Pavement Engineering on the map at the Faculty several decades ago. The baton was passed on to Prof Kim Jenkins who has been the incumbent of the SANRAL Chair since its establishment in 2001. This New Pavement Laboratory will lay the foundation for a younger generation to carry on with research in this important field for many decades to come.

Research Output	
Journal Articles (subsidised)	37
Proceedings International	39
Proceedings National	10
Doctoral completed	11
Master’s completed	54



Prof Jan Wium
Chair: Civil Engineering.

3D Printing of Concrete



Frederick Bester demonstrating 3D printing of concrete at the Open Day.

3D printing of concrete (3DPC) promises to become a disruptive technology in the construction industry. It has the potential to reduce construction times and waste drastically, while also enhancing architectural freedom through its ability to produce geometrically-complex elements when compared to traditional methods of construction.

Various institutions, private, commercial and academic, are exploring the possible application of 3DPC within the construction industry. Subsequently the Centre for Development of Sustainable Infrastructure (CDSI) at Stellenbosch University launched a research programme on 3DPC. Whilst pursuing the advancement of digital construction, PhD candidate Jacques Kruger designed and manufactured a laboratory size gantry-type 3D concrete printer in the Building Materials and Structure Laboratories located in the Division of Structural Engineering and Civil Engineering Informatics. The outer dimensions of the concrete printer are 1,3 x 1,3 x 1,67 m (w x l x h) and provides a build volume of roughly 1 m³. A three-phase pump, controlled via a variable frequency drive, permits 3DPC with a wide range of rheological properties, offering versatility in constructing laboratory scale structures and structural elements.

Despite all the advantages 3DPC promises, the industry lacks test methods to quantify the buildability of a printable concrete. Buildability refers to the capacity of a printable concrete to withstand the stress imposed by consecutively deposited layers without failure or excessive deformation of the printed object.

Therefore, in a study, Frederick Bester developed and printed multiple 3D benchmarking structures to assess the buildability of a concrete mixture. Through the printing process, the benchmarking structures quantify the capacity of a cement-based material to retain sufficient stability and shape under a reasonable wall gradient and height. These benchmarking structures enable 3DPC institutions to systematically quantify the performance of their 3D printable concrete and facilitate industry-wide data collection. Additionally, these benchmarking structures present a criterion which is ultimately essential for the advancement of this novel technology before it becomes widely accepted as an alternative to traditional forms of construction.

In Frederick's research, he conducted a finite element analysis (FEA) to analyse the material properties of a printable concrete mixture developed at the CDSI. The analysis was based on time-dependent material properties, specifically a linear Young's Modulus and Mohr-Coulomb failure criterion within 0 to 45 minutes after material extrusion. Through FEA, several benchmarking structures were evaluated, including a hollow cylindrical column, half sphere, and ascending and descending vertex cones. Each benchmark exhibits different failure modes of material and ultimately a structural failure, thus providing insight into the limitations of the printable concrete mixture. Subsequently, the analyses of benchmarking structures were validated through 3D printing which display a strong correlation with the results of the FEA.

Structural Engineering

Research is carried out on construction materials, steel and concrete structures, structural reliability, fire engineering, as well as sustainability of the built environment. Structural reliability considers probabilistic load and resistance provisions. Research in fire engineering includes computational and experimental investigation of structural performance in a fire, fire spread and fire loads. Sustainability of the built environment includes durability of materials and structures, objective modelling and subsequent minimisation of environmental impact.

Civil Engineering Informatics

Civil Engineering Informatics focuses on the needs of the civil engineering practice in an information-driven environment. Application of Information Technology in civil engineering is concerned with collaborative engineering, intelligent modelling of the design process in structural engineering, support systems for engineering management and technical aspects of urban engineering.

Water and Environmental Engineering

Research fields include water resources development, flood hydrology, environmental water requirements, the design of large hydraulic structures such as dams higher than 100 m, river abstraction works and bridges, river hydraulics, sediment yield and fluvial morphology of rivers and estuaries, reservoir and harbour sedimentation, coastal engineering, port engineering and design, breakwaters, coastal and estuarine hydro- and sediment dynamics, dredging, coastal environmental studies, hydrodynamic modelling of river, lake and estuary flow patterns and water quality, water and wastewater treatment, stormwater systems and water services which include bulk water supply, water demand and water conservation, end-use modelling, alternative water sources, peak flows, stormwater quality, small-scale water treatment systems, hydraulic modelling of water systems, system pressure, pressure management, leaks and intermittent supply.

Transportation and Geotechnics

Geotechnics research focuses on the upper quaternary sands of the Cape Flats and its engineering geological characterisation in terms of its compressibility, shear strength, hydraulic conductivity and volumetric behaviour during shear (liquefaction potential). Ongoing geological investigations at Matjiesfontein are also carried out in support of the construction of the Space Geodesy Observatory.

Student-orientated research in pavement engineering includes accelerated testing of asphalt including MMLS testing and beam fatigue tests, environment-friendly bitumen stabilised materials researched using triaxial and fatigue tests, development of a performance-related seal design method for bitumen and modified binders, and a mix design and analysis system of asphalt bases.

Research is carried out on Road Safety and Intelligent Transport Systems (ITS). Road Safety research includes road crash causation, the influence of human factors, the role of geometric design, speed, public transport safety, and pedestrian safety factors. Research in ITS focuses on public transport user information, multimodal data base development, appropriate technology applications in developing countries and freeway management information applications for travel time estimation and incident management systems.

Construction Engineering and Management

Research addresses the management and development of multidisciplinary capital projects. It focuses on modular construction, construction risk, design management, constructability, and advanced technologies in construction.

Geotechnical, Management and Transportation Engineering

Chair
Prof Jan Wium
CONSTRUCTION ENGINEERING
AND MANAGEMENT.
janw@sun.ac.za



Prof Marion Sinclair
TRANSPORTATION ENGINEERING
AND ROAD SAFETY.
msinclair@sun.ac.za



Prof Kim Jenkins
SANRAL CHAIR: Pavement Engineering.
kjenkins@sun.ac.za



Prof Johann Andersen
INTELLIGENT TRANSPORT SYSTEMS.
jandersen@sun.ac.za



Prof Fred Hugo
ACCELERATED PAVEMENT TESTING.
fhugo@sun.ac.za



Prof Peter Day
GEOTECHNICAL ENGINEERING.
day@jaws.co.za



Dr Chantal Rudman
PAVEMENT ENGINEERING.
rudman@sun.ac.za



Dr Charles MacRobert
FUNDAMENTAL GEOTECHNICS.
macrobert@sun.ac.za



Mr Leon Croukamp
GEOTECHNICAL GIS APPLICATIONS.
lcroukamp@sun.ac.za



Mr Chris Jurgens
CONSTRUCTION ENGINEERING
AND MANAGEMENT;
Project management.
cj@sun.ac.za



Ms Megan Bruwer
TRANSPORTATION ENGINEERING:
Intelligent transport systems.
mbruwer@sun.ac.za



Ms Nanine Fouché
GEOTECHNICAL ENGINEERING.
naninef@sun.ac.za



Structural Engineering and Civil Engineering Informatics

Prof Celeste Viljoen
RELIABILITY OF STRUCTURES:
Concrete structures; Standardisation.
cbarnardo@sun.ac.za



Prof Gideon van Zijl
COMPUTATIONAL AND
STRUCTURAL MECHANICS:
Cement-based materials.
gvanzijl@sun.ac.za



Prof Johan Retief
RELIABILITY AND RISK ANALYSIS.
jvr@sun.ac.za



Dr Breda Strasheim
ENGINEERING MECHANICS:
Civil engineering informatics;
Engineering management.
javbs@sun.ac.za



Prof Trevor Haas
EARTHQUAKE ENGINEERING.
trevor@sun.ac.za



Dr Gert van Rooyen
CIVIL ENGINEERING INFORMATICS:
Engineering management.
gcvr@sun.ac.za



Dr Hennie de Clercq
STEEL STRUCTURES.
clercq@sun.ac.za



Dr Roman Lenner
RELIABILITY OF STRUCTURES:
Bridge load models; Concrete structures.
rlenner@sun.ac.za



Dr Riaan Combrinck
CONCRETE TECHNOLOGY.
rcom@sun.ac.za



Dr Richard Walls
FIRE ENGINEERING:
Steel structures; Demolition.
rwalls@sun.ac.za



Ms Wibke de Villiers
SUSTAINABILITY OF THE BUILT
ENVIRONMENT:
Masonry structures.
wdv@sun.ac.za



Mr Algurmon van Rooyen
CONCRETE TECHNOLOGY:
Engineering mechanics.
asvr@sun.ac.za



Mr Pierre van der Spuy
BRIDGE ENGINEERING.
pierreavds@sun.ac.za

Water and Environmental Engineering

Prof Heinz Jacobs

HYDRAULICS;
Water services planning.
hejacobs@sun.ac.za



Prof Gerrit Basson

RIVER HYDRAULICS; SEDIMENTATION;
DESIGN OF HYDRAULIC STRUCTURES.
grbasson@sun.ac.za



Prof Kobus du Plessis

HYDROLOGY;
ENVIRONMENTAL ENGINEERING.
jadup@sun.ac.za



Prof Koos Schoonees

TRANSNET CHAIR;
Port and Coastal Engineering.
kooss@sun.ac.za



Dr Isobel Brink

WATER AND WASTEWATER TREATMENT;
ENVIRONMENTAL ENGINEERING;
Wastewater and potable
water treatment; Stormwater
quality; Bio-filtration.
icbrink@sun.ac.za



Dr André Theron

PORT AND COASTAL ENGINEERING;
Coast and estuarine hydro- & sediment-
dynamics; Coastal environmental studies.
aktheron@sun.ac.za



Ms Adèle Bosman

HYDRAULICS.
abosman2@sun.ac.za



Mr Carlo Loubser

HYDROLOGY;
Water services planning.
carloloubser@sun.ac.za



Electrical and Electronic Engineering



Master's student, Anton Erasmus, preparing a rotary wing UAV for autonomous flight test.



Prof Dirk de Villiers (back far right), holder of the SARCHI-SKA Chair, with his research group which includes colleagues and postgraduate students.

SARCHI-SKA Chair gets new incumbent

2018 saw a change in the SARCHI-SKA Chair housed in the Department of Electrical and Electronic Engineering. Prof Dirk de Villiers, the new holder of this chair from 1 January 2018, says: "The Faculty of Engineering at Stellenbosch University is the only Engineering faculty to have been awarded an SKA Chair. The first phase of the design work on the ambitious project, the Square Kilometre Array Radio Telescope, has been completed. Stellenbosch University contributed in the electromagnetic design of the reflector antennas as well as plenty of work on keeping the site and systems free from radio frequency interference. The next phase now focuses on developing even more sophisticated and exotic antenna elements and systems – able to do more science in the same time.

"The main aim of the Chair, however, is to deliver expert postgraduate students who can work in the

high frequency arena in a variety of applications – besides just radio astronomy. In 2018 in the order of R2 million was made available for bursaries to students resorting under the Chair, and in 2019 this amount will be R3 million. Bursaries are funded by the South African Radio Observatory (SARAO) directly and through the SKA Chair."

Prof De Villiers concludes: "A major part of the SKA Project is based in South Africa. However, we work in close collaboration with large astronomical institutes overseas, such as ASTRON in The Netherlands and Cambridge University in Great Britain."

Novel biosensor for early detection of cancer

The smart approach to research these days is for different disciplines to work together to complement each other and to increase the impact of the research.

A perfect example of such an interdisciplinary project is the work done by Prof Willie Perold, an electronic

engineer in the Department of Electrical and Electronic Engineering, and Prof Resia Pretorius (Department of Physiological Sciences in the Faculty of Science) who is an expert on blood cell morphology. Together they are working on a novel hand-held nano-electronic biosensor that will use only one drop of blood to diagnose cancer more rapidly and at a lower cost than current methods.

“We have been working together for some time and are co-supervising three postgraduate students,” says Prof Perold. “Currently, we are working on the early detection of inflammatory conditions, such as cancer. Two of our projects investigate the occurrence of the protein serum amyloid A (SAA). This protein is interesting as it increases noticeably when there is inflammation in the body.”

Prof Pretorius confirms this: “In full-blown stage 3 cancer, SAA levels are 1 000 times higher than normal. A great increase in serum amyloid A in the blood therefore is a sign that something is wrong.”

Prof Perold adds: “With our biosensor we aim to pick up the onset of inflammation during the early stages by the detection of SAA in the blood sample. Long before cancer manifests, it should therefore be traceable through the high levels of SAA that gives it away.”

In order to develop the small biosensor, Prof Perold builds on a previous project in which a similar device was developed to detect Escherichia coli in a few minutes.

Project on superconducting integrated circuits amounts to over R30 million

Prof Coenrad Fourie is the co-Principal Investigator on a project funded by the United States Intelligence Advanced Research Projects Activity, IARPA. In collaboration with the Principal Investigator at the University of South California, Prof Massoud Pedram,

and other world-renowned colleagues from the Universities of Florida and Syracuse in the USA, the University of Savoie Mont Blanc in France and Yokohama National University in Japan, Prof Fourie and his team of engineers, postdoctoral fellows and PhD and master’s degree students are developing integrated circuit design software and cell libraries for ultra-energy efficient superconducting digital circuits.

The software will enable the design of 64-bit Reduced Instruction Set Computer processors for superconducting circuits with clock frequencies approaching 100 GHz. Such processors could be used in next-generation low-energy supercomputers. Other applications of the design software, which includes powerful electromagnetic solvers, inductance calculation tools and magnetic field interference and flux trapping analysis capabilities are the design of magnetic field-tolerant quantum electronics interface circuits. At Stellenbosch, the team consists of three engineers, a postdoctoral fellow, three PhD students and six master’s degree students.

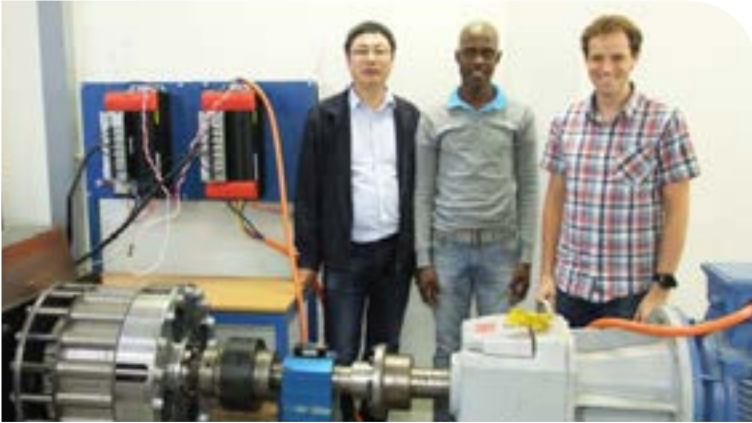
The project has multiple phases spread over five years, with a total of about R30 million budgeted for the Stellenbosch group.

Research Output	
Journal Articles (subsidised)	38
Proceedings International	55
Proceedings National	14
Books	1
Patents	1
Doctoral completed	9
Master’s completed	43



Prof Herman Engelbrecht
Chair: Electrical and Electronic Engineering.

The Magnetic Gear – an attractive, innovative technology



A magnetically-gear permanent magnet wind generator system. Research team members from the left are Prof Rong-Jie Wang, Pushman Tlali (PhD student) and Dr Stiaan Gerber (postdoctoral fellow).

Gears can change the speed and torque of an input source creating a mechanical advantage through their gear ratios. The earliest gears date from 4th century BC. Nowadays, mechanical gears are widely used in many industries. However, they are subject to wear, overheating, are often damaged in an over-torque situation and require periodic lubrication and maintenance. Gear failures not only incur high repair costs, but also cause the loss of production. In wind power industry alone, gearbox failures account for the largest amount of downtime, maintenance and loss of power generation.

The magnetic gear is an attractive innovative technology that can transfer torque between two rotors. The rotors spin at different speeds, determined by the gear ratio, but there is no physical contact between the rotors. Because of this contactless torque transfer mechanism, magnetic gears can offer significant advantages over mechanical gears such as lower maintenance, improved reliability and inherent overload protection. Owing to the poor torque capability, magnetic gear technology received little attention in the past. However, with the availability of high energy permanent magnet (PM) material and especially new design topologies, magnetic gears hold promise to outperform traditional mechanical gears in certain applications.

Over the past decade, the Department of Electrical and Electronic Engineering has made significant inroads into the research on magnetic gears and magnetically-gear electrical machines. In 2009, researchers based in the Electrical Machines Laboratory (EMLab) developed the first magnetic gear prototype on the African continent, which was also one of the few early

prototypes of modern magnetic gears in the world. The concentric structure of magnetic gears offers a unique possibility to integrate a PM machine with a magnetic gear within a single volume resulting in a new class of torque dense and compact electrical machines, termed magnetically-gear electrical machines (MGEM).

From 2013, the research on these MGEM received funding support from ABB Corporate Research in Sweden. Researchers at EMLab developed and critically evaluated a number of magnetically-gear machine technologies for wind power applications. Owing to their superb torque density and performance, these special machines can also find applications in mining, electrical transport, renewable energy, pharmaceutical and food, aerospace and marine industries.

As a part of a recent EU H2020 project in collaboration with the Department of Mechanical and Mechatronic Engineering, researchers at the EMLab looked into air-cooled condenser drive systems for coal-firing and concentrated solar power plants, where shock loads and excessive starting torque led to a high failure rate of mechanical gears. The research indicates that magnetic gears may be a good candidate to replace mechanical gears in this application, since they can handle shock loads while achieving high efficiency.

Despite the various advantages that magnetic gears can offer, there are no commercial magnetic gears available in the world. Together with other leading research laboratories in Europe and the United States, the EMLab strives to further improve and mature the magnetic gear technology. The ultimate goal of this research is to get the technology ready for commercialisation.

Robotics

In the Electronic Systems Laboratory (ESL), research, development and projects concentrate mainly on the control of remote sensing platforms. These platforms include satellites (e.g. CubeSats), manned and unmanned aerial vehicles (UAVs) as well as autonomous underwater vehicles (AUVs) and unmanned ground vehicles. As most of the research is done as part of a larger system, students are exposed to the full breadth of the management and technical activities required in complex system development.

Electromagnetics

Current activities focus on the following projects: RF and microwave antennas for communications and radar systems, FEM, FDTD and MoM modelling of antennas and wave propagation in complex electromagnetic environments, development of numerical methods and software for simulation of electromagnetic fields, free-space and near-field measurement techniques, optimising complex antennas and microwave components, the Karoo Array Telescope (KAT) and the Square Kilometre Array (SKA). Other activities include superconducting elements, nanosensors, electromagnetic compatibility, microwave filters and non-linear circuits. An antenna and microwave laboratory, supported by sophisticated instrumentation and powerful computing facilities, provides the infrastructure for research work.

Electrical Energy

This division focuses in research on electrical energy in terms of conversion, distribution, control and management, and renewable energy. Specifically, attention is given to multilevel power electronic converters, electrical machine design and drive systems, energy efficiency, and the measurement and management of electrical energy. In renewable energy, the focus is on photovoltaic solar energy, wind generator systems, system identification and grid integration. The facilities include world-class laboratories and instrumentation for prototype testing and measurement. The Department has the only high-voltage laboratory in the Western Cape for amongst others advanced insulator tests and research.

Telecommunications and Informatics

This division works in a variety of areas that involve the manipulation of information-bearing signals. This comprises both extracting and embedding information in the signal (digital signal processing), the transmission of such signals over large distances (telecommunication) and through complex networks (communication networks), and the automatic learning and recognition of the signal content (machine learning) with particular focus on speech and image signals, as well as specialised sensor signals.

Telecommunications and Informatics

Chair

Prof Herman Engelbrecht

NETWORKS AND DISTRIBUTED SYSTEMS:
Networking and networked applications;
Distributed virtual environments;
Machine learning.
hebrecht@sun.ac.za



Prof Johan du Preez

SPEECH PROCESSING AND PATTERN
RECOGNITION: Speaker, speech and
language recognition.
dupreez@sun.ac.za

Prof Thomas Niesler

SPEECH PROCESSING AND PATTERN
RECOGNITION: Speaker, speech and
language recognition.
trn@sun.ac.za



Prof Jaco Versfeld

TELECOMMUNICATIONS AND
SIGNAL PROCESSING: Forward error
correction, Digital communication
systems, Array processing.
djversfeld@sun.ac.za

Dr Herman Kamper

MACHINE LEARNING AND
PATTERN RECOGNITION: Speech,
vision and language processing.
kamperh@sun.ac.za



Mr Rensu Theart

DATA VISUALISATION AND MACHINE
LEARNING: 3D microscopy data
visualisation and analysis; Virtual reality
applications; Machine learning.
rpthcart@sun.ac.za

Robotics

Prof Thinus Booysen

VEHICULAR AND COMPUTER
SYSTEMS: The internet of
things, applied to transport,
energy and water.
mjbooyesen@sun.ac.za



Prof Herman Steyn

AEROSPACE & INDUSTRIAL CONTROL
SYSTEMS: Satellite systems; Satellite orbit
and attitude control; Process control;
Adaptive control.
whsteyn@sun.ac.za

Dr Japie Engelbrecht

AEROSPACE CONTROL SYSTEMS:
Manned/unmanned aircraft flight
control and navigation;
Airbus collaboration contact point.
jengelbr@sun.ac.za



Dr Willem Jordaan

SATELLITE CONTROL SYSTEMS: Satellite
systems; Satellite orbit and attitude
control; Process control; Adaptive control;
Embedded systems.
wjordaan@sun.ac.za

Dr Corné van Daalen

AUTONOMOUS SYSTEMS:
Autonomous navigation, planning,
conflict detection and resolution.
cvdaalen@sun.ac.za



Dr Lourens Visagie

COMPUTER SYSTEMS:
Embedded programming;
Satellite control systems.
lvisagie@sun.ac.za

Mr Arno Barnard

COMPUTER SYSTEMS: Space vehicle
electronics; FPGA and DSP design;
Microcontrollers; Radiation influence
and mitigation techniques.
abarnard@sun.ac.za



Mr Willem Smit

DIGITAL HARDWARE: FPGA and
DSP design; Camera systems
and security applications.
wsmit@sun.ac.za

Electrical Energy

Prof Maarten Kamper

ELECTRICAL MACHINE SYSTEMS:
Electrical machine design; Electrical
drives and control; Renewable
energy generator systems.
kamper@sun.ac.za



Prof Toit Mouton

POWER ELECTRONICS: Converter
technology; Multilevel converters;
AC to DC converters; Control of
power electronic converters.
dtmouton@sun.ac.za



Prof Johan Vermeulen

LOAD MODELLING AND RENEWABLE
ENERGY: Load modelling; Energy
management; Grid integration of
renewable energy.
vermeuln@sun.ac.za



Prof Rong-Jie Wang

ELECTRICAL MACHINE SYSTEMS: Special
electrical machines; Finite element
modelling; Renewable energy systems;
Thermal analysis in power devices.
rwang@sun.ac.za



Dr Johan Beukes

POWER ELECTRONICS AND
APPLICATIONS: Utility applications
of power electronic converters.
jbeukes@sun.ac.za



Dr Arnold Rix

PHOTOVOLTAIC SYSTEMS: Solar
PV technology; Rooftop and
utility scale solar PV; Performance
monitoring; Network integration.
rix@sun.ac.za



Dr Bernard Bekker

ESKOM CHAIR:
Power System Modelling.
bbekker@syn.ac.za



Dr Johann Strauss

ELECTRICAL ENERGY SYSTEMS:
Efficient energy conversion;
Linear generators.
jstrauss@sun.ac.za



Dr Nkosinathi Gule

ELECTRICAL MACHINES AND DRIVES:
Multiphase induction machine
drives and control; Renewable
energy and power systems.
nathie@sun.ac.za



Mr Nelius Bekker

POWER SYSTEM MODELLING:
Demand-side management;
Measurement and verification;
Renewable energy systems;
Parameter estimation.
neliusb@sun.ac.za



Ms Karen Garner

ELECTRICAL MACHINE SYSTEMS:
Electrical machine design;
Renewable energy generator
systems; High voltage systems;
Transmission design.
garnerks@sun.ac.za



Mr Fredrick Mwaniki

POWER ELECTRONICS;
ELECTRICAL DRIVES:
Renewable energy; Power systems.
fmmwaniki@sun.ac.za



Electromagnetics and Electronics

Prof Matthys Botha

COMPUTATIONAL ELECTROMAGNETICS:
Numerical techniques for EM analysis.
mmbbotha@sun.ac.za



Prof Johann de Swardt

MICROWAVE ELECTRONICS:
Non-linear microwave circuits;
Microwave active components.
deswardt@sun.ac.za

Prof Dirk de Villiers

SARCHI RESEARCH CHAIR:
Antenna Systems for SKA.
ANTENNAS AND MICROWAVES:
Design and modelling of antennas and
microwave passive devices.
ddv@sun.ac.za



Prof Coenrad Fourie

ELECTRONICS: Superconductor circuits;
SQUID magnetometry; Geomagnetism
and space weather monitoring;
VLSI inductance extraction.
coenrad@sun.ac.za

Prof Petrie Meyer

MICROWAVE CIRCUITS: Network
synthesis; Microwave filters; Low-noise
amplifiers; Numerical modelling.
pmeyer@sun.ac.za



Prof Willie Perold

ELECTRONICS: Superconducting
Josephson circuits; SQUID sensors;
Nanotechnology sensing devices.
wjperold@sun.ac.za

Dr Jacki Gilmore

ANTENNAS: South African
Square Kilometre Array; Antenna
element and feed design;
Electromagnetic modelling.
jackivdm@sun.ac.za



Dr Danie Ludick

COMPUTATIONAL ELECTROMAGNETICS:
Fast numerical methods;
High performance computing.
dludick@sun.ac.za

Dr Elmine Meyer

MICROWAVE CIRCUITS:
Tunable microwave filters.
elmine@sun.ac.za



Dr Carlo van Niekerk

ANTENNAS AND PROPAGATION:
Electrically small antennas;
Antenna circuit modeling;
Radar target design;
Embedded antenna design.
cvanniekerk@sun.ac.za



Dr Gideon Wiid

HIGH FREQUENCY SYSTEMS: South African
Square Kilometre Array; Electromagnetic
compatibility; RFI characterisation; Metrology.
wiidg@sun.ac.za

Industrial Engineering



In the Stellenbosch Learning Factory: Prof Louis Louw (far right) explains the application of robotics within a smart manufacturing environment to students.



Clockwise from the left: the exterior of the new Industrial Engineering building; the large, modern lecture room; and the top-class board room.

A new building for Industrial Engineering – at last!

The Department of Industrial Engineering, which was established in 1984 as the Faculty's fifth department, was delighted to move into its own building mid-2018 after sharing facilities with the Department of Mechanical and Mechatronic Engineering ever since its inception.

With rising student numbers this Department needed more space. Furthermore, over the past few years the Department of Industrial Engineering excelled in many aspects, an important one being a radical increase in postgraduate student numbers and research output. In 2017, the Department even delivered a Chancellor's Medal winner, Jacqueline Kazmaier. Consequently, after 34 years, Industrial Engineering can now truly claim that it is a department with its own solid identity which justifies having an own building.

The old Information Technology building, nestled just behind the General Engineering building, was earmarked for this purpose. R38 million was spent on refurbishment according to the needs of Industrial Engineering. It was designed for an undergraduate class size of 130 students and has open plan office space for 180 postgraduate students. Computer laboratories provide 50 equipped work stations and can accommodate 132 bring-your-own-device students.

Spanning over five floors, the modern new Industrial

Engineering building has several meeting rooms and kitchenettes as well as a top-class board room.

Department takes the lead in the field of Data Science

At their first meeting in May 2018 with Faculty management, Engineering's reconstituted Advisory Board stressed that the Faculty must prepare the young generation to work in a deluge of data. They were preaching to the converted, as the Faculty was already deeply aware of the importance of this field and had already taken steps in this regard. In 2018 a lot of preparation was done to establish the Voigt Chair in Data Science in the Faculty, and departments were invited to send in proposals for housing this Chair.

The Department of Industrial Engineering is extremely pleased that it was awarded the Chair on the strength of its proposal. During 2018 the Department put in a lot of effort to find a potential holder with stature in the field. It was indeed a triumph when Industrial Engineering managed to recruit Prof Andries Engelbrecht to join Stellenbosch University in January 2019 as the first incumbent of the Voigt Chair in Data Science.

Prof Engelbrecht is an an A-rated researcher as rated by the National Research Foundation (NRF). This rating acknowledges that he is a leading international researcher in his field.

Prof Engelbrecht says: "Regarding my position as Chair, my main aim will be to promote Data Science within

Stellenbosch University. This includes the transfer of knowledge to undergraduate and postgraduate students as well as to industry. In order to do this, I want to establish a research group within the Department of Industrial Engineering and I will bring two bright young colleagues on board, namely Prof Jacomine Grobler and Dr Thorsten Schmidt-Dumont.”

Prof Wim de Villiers (Rector and Vice-Chancellor of Stellenbosch University) who is a great advocate for Data Science as an important academic and research field, says: “The generation of, access to, and use of data have exploded worldwide over the last decades. Stellenbosch

University has a number of activities and experts in this area spread over almost all ten of our faculties, and all five of our campuses, but we realised that these assets are not optimally organised and integrated. So, we are planning to establish the Stellenbosch School for Data Science and Computational Thinking, which will work across all our faculties in an interdisciplinary way and will span the entire academic project, from under- and postgraduate training to research and specialist consultation. Engineering will play a key role in the new School. The Dean, Prof Wikus van Niekerk, is one of its most enthusiastic supporters.”

Industrial Engineering is proud that it has taken the lead in the field of Data Science with the establishment of the Voigt Chair in Data Science.

Large grant, exciting collaboration and multidisciplinary research

The Stock Visibility Solution (SVS), developed for the SA National Department of Health, by a major mobile service provider, is a mobile phone-based solution that provides real-time visibility on stock levels at primary healthcare dispensaries in South Africa. What is truly exceptional about this initiative is that it has been deployed at more than 3 200 clinics across eight provinces in South Africa. The SVS provides a mechanism through which stakeholders can monitor and manage stock levels and by extension manage critical public sector supply chain and procurement processes.

Through an exciting collaboration with Mezzanine ware, the Department of Industrial Engineering has embarked on a high-impact initiative enabled through a Grand Challenges Exploration grant from the Bill and Melinda Gates Foundation. This has resulted in a multidisciplinary research programme between

researchers from three of the Department’s research groups, Health Systems Engineering and Innovation Hub (HSE&IH), Stellenbosch Unit for Operations Research in Engineering (SUnORE) and Supply Chain Management. The researchers are Prof Sara Grobbelaar (HSE&IH), Prof Jan van Vuuren (SUnORE) and Dr Joubert van Eeden (Supply Chain Management).

Project partners also include supply chain experts from Prof Nico van Daele’s research group at KU Leuven in Belgium where he holds the GSK Research Chair on Access-To-Medicines in Developing Countries.

The grant supports six master’s and PhD students with a further five final-year projects that have

been initiated to bolster the activities. The programme has as a core goal the development of real innovations that could be integrated in the SVS environment. These tools will inter alia 1) help hospitals and clinics manage their stock levels better; 2) develop a risk evaluation model that utilises machine-learning techniques to forecast which clinics are at risk of stock-outs; 3) use artificial intelligence to explore the utilisation of self-organisation in supply networks and what that means for re-ordering policies; and 4) utilise agent-based modelling to forecast the spread of epidemics and resultant demand for medicines.

The programme also includes a number of system analysis projects that will help guide the innovation programme going forward such as 1) creating a maturity model for evaluating readiness of a supply network to utilise stock visibility data; 2) exploring the platform innovation ecosystem around public medicine supply chains; and 3) develop an evaluation tool to determine the socio-economic impact and value for money measures of the SVS solution.



Prof Corne Schutte
Chair: Industrial Engineering.

Research Output	
Journal Articles (subsidised)	59
Proceedings International	34
Proceedings National	30
Chapters in Books	8
Doctoral completed	9
Master’s completed	40

Helping computers to analyse opinions and leveraging sentiment analysis in decision making



Prof Jan van Vuuren and Jaqueline Kazmaier (master's student).



Public opinion has been an area of interest for centuries. Historic leaders have tried to gauge the fighting spirit of their soldiers prior to battle, just as members of political campaigns attempt to quantify the amount of support that has been secured for an upcoming election. With the rapid growth of the social media, blogs and review sites, and the resulting increase in the number of user-generated content publicly available online, this interest has become even more pronounced.

This gave rise to the field of *sentiment analysis* or *opinion mining* – the computational study of people's opinions, attitudes and emotions. Applications of this young and rapidly growing area of research are vast. Shifts in public sentiment have, for example, been shown to correlate with companies' stock prices. Furthermore, they have also proven to be good indicators of violent uprisings, such as the Arab Spring.

Whereas the task of sentiment parsing is relatively easy for humans, nuances of natural languages make it inherently difficult for computers. This is especially true in the South African context, where opinion-bearing expressions may be composed in up to eleven different languages. Furthermore, while there is an abundance of research dedicated to developing algorithms for the purpose of classifying sentiment, little guidance exists on how to incorporate this information into the decision-making process of affected entities.

In 2018, the *Stellenbosch Unit for Operations Research in Engineering* (SUNORE), situated within the Department of Industrial Engineering, began to conduct research addressing these problems. Current and possible future research topics within the unit include:

- Developing a framework for evaluating unstructured customer feedback, which incorporates text pre-processing, the construction and evaluation of machine learning models for analysing the sentiment contained in customer reviews, as well as the extraction of actionable insights from the results of such analyses (with a case study in the South African banking sector).
- Evaluating the effectiveness of various text representation models used to translate paragraphs of text into a vectorised format. These vector representations serve as input to machine learning algorithms for sentiment classification (again with case studies in the South African banking sector).
- Developing algorithms capable of simultaneously classifying topic and sentiment.
- Using sentiment data to predict events or attributes of interest.
- Addressing the lack of available corpora and lexica for sentiment analyses of low-resource languages, such as Xhosa, Zulu or Afrikaans.

The research conducted within the unit is aimed at contributing both to the development of effective models for sentiment analysis, especially in the South African context, as well as leveraging sentiment information for decision making in practice. Students involved in this research have attended relevant workshops and presentations at the continental Deep Learning Indaba and have presented their work at the national conference series of the Operations Research Society of South Africa.

Engineering Management

Includes fields such as project-, risk-, innovation-, quality- and performance management, and feasibility studies in the wider sense:

- Enterprise Engineering: analysis of enterprises (design, implement, operate) including knowledge and information-, innovation-, financial- and technology management.
- Sustainable Systems: the transition to a more sustainable economy and society, placing emphasis on management of infrastructure/technology, including planning and design.
- Health Systems Engineering: conceptualising novel, engineering-based solutions to challenges facing the healthcare sector.
- Innovation for Inclusive Development: analysis, development and evaluation of inclusive innovations, inclusive innovation systems and innovation platforms.
- Industrial Policy and Beneficiation of Minerals: Investigates how mineral rich countries may optimally leverage their mineral endowments for sustainable development.

Manufacturing

This area focuses on development of resource efficient process chains to ensure sustainable manufacturing as value creation system of products, but also for wider application in the services sector.

- Smart Sustainable Advanced Manufacturing: The co-creation of manufactured products through digital, economically-sound process chains that minimise negative environmental impacts, while conserving energy, natural resources and empowering communities.
- Additive Manufacturing: An emerging technology used to manufacture customised products like a maxillofacial implant surgically inserted into patients who have lost significant portions of their facial bone structure due to cancer and other diseases.
- Micromanufacturing: The micromachining (milling and turning) and microassembly of microproducts in which micromaterial handling systems are utilised.

Operations Management

Operations & Supply Chain Management focuses on process excellence from both intra-organisational and inter-organisational points of view.

- Physical Asset Management: The systematic and coordinated activities through which organisations optimally and sustainably manage their assets over their respective life-cycles.
- Supply Chain Management: A key research focus is on the digitalisation of operations, supply chains, and

value chains in both the manufacturing, retail, and service environments.

- Learning Factories: The Stellenbosch Learning Factory provides a research facility for research topics related to the “smart factory” of the future (in line with the 4th industrial revolution movement).
- PRASA Engineering Research Chair: Strategic decisions must be supported by a sound corporate baseline which is founded on scientific merit. This in turn requires that the operations of PRASA be analysed and improved on in terms of efficiency and effectiveness.

Systems Modelling, Operations Research and Decision Support

Focuses on the development of mathematical models and their incorporation into computerised systems aimed at supporting scientifically justifiable and effective decisions in industry. These models draw from the scientific fields of applied mathematics, statistics, industrial engineering and computer science and are applicable in the context of complex problems which admit a large variety of trade-off solutions. Examples:

- Routing and scheduling decisions for fleets of delivery vehicles.
- Employee duty roster or timetabling decisions for the manufacturing and health sectors.
- Shelf-space allocation and inventory decisions for retailers.
- Crop irrigation and agricultural pest-control strategy decisions.
- Power generator maintenance scheduling decisions in the energy sector.
- Facility location decisions for effective supply chain logistics.
- Optimal facility or production plant layout.

Data Science

Focuses on the development of innovative machine learning and optimisation techniques to produce novel, efficient and robust data science technologies, for use in Industrial Engineering and Engineering Management applications. Data science techniques can be used on extremely large data sets to computationally reveal patterns, trends and associations, especially relating to human behaviour and interactions. Examples include:

- Forecasting customer demand from millions of retail transactions to understand demand patterns.
- Determining the optimal segmentation of customers to customise service delivery and develop targeted marketing strategies.
- Using machine learning to predict order delivery times in a distribution scenario.
- Analysing imaging data for real-time inventory decision making.

Contacts

Chair

Prof Come Schutte

ENTERPRISE ENGINEERING AND
PROJECT MANAGEMENT:

Knowledge management; Innovation;
Enterprise life-cycles; Project, programme,
risk and communication management;
PMBOK, Engineering management.
come@sun.ac.za



Prof Jan van Vuuren

OPERATIONS RESEARCH:
Combinatorial optimisation; Vehicle
routing; Scheduling and timetabling;
Facility location; Decision support
systems; Graph and network theory.
vuuren@sun.ac.za

Prof Andries Engelbrecht

VOIGT CHAIR IN DATA SCIENCE:
Swarm intelligence; Evolutionary
computation; Machine learning;
Optimisation; Data analytics;
Artificial intelligence.
engel@sun.ac.za



Prof Neels Fourie

PRASA ENGINEERING RESEARCH CHAIR:
Project, Programme & Risk management;
Rail engineering; Maintenance management;
Reliability improvement.
cjf@sun.ac.za

Prof Wessel Pienaar

LOGISTICS AND TRANSPORTATION
SYSTEMS ANALYSIS:
Transport operations and infrastructure
planning; Traffic flow theory and
transportation analysis.
wpienaar@sun.ac.za



Prof André van der Merwe

RESOURCE EFFICIENCY -
ENGINEERING MANAGEMENT:
Additive manufacturing; Ergonomics
(human factors); Commercial readiness.
andrevdm@sun.ac.za

Prof James Bekker

OPERATIONAL SYSTEMS DESIGN:
Information systems;
Computer simulation;
Multiobjective optimisation.
jb2@sun.ac.za



Prof Sara Grobbelaar

INNOVATION AND TECHNOLOGY
MANAGEMENT:
Health systems engineering and
innovation; Innovation systems &
ecosystems; Innovation for inclusive
development; ICTs for development.
ssgrobbelaar@sun.ac.za

Prof Stephen Matope

MANUFACTURING AND INDUSTRIAL
MANAGEMENT:
Micromanufacturing;
Additive manufacturing; Robotics;
Production management.
smatope@sun.ac.za



Prof Louis Louw

ENTERPRISE ENGINEERING AND OPERATIONS
& SUPPLY CHAIN MANAGEMENT:
Enterprise (re)design; Innovation
management; Production management;
Digitalisation in operations & supply chains.
louisl@sun.ac.za

Prof Jacomine Grobler
 SUPPLY CHAIN DATA SCIENCE
 AND OPTIMISATION:
 Data science; Optimisation algorithm
 development; Supply chain
 management.
 jacominegrobler@sun.ac.za



Mr Konrad von Leipzig
 ENGINEERING MANAGEMENT:
 Engineering management; Strategic
 operations management; Supply chains;
 Engineering economics and finances;
 Clustering and business modelling.
 kvl@sun.ac.za

Dr Wyhan Jooste
 PHYSICAL ASSET MANAGEMENT:
 Maintenance management;
 Reliability engineering; Asset
 management methodologies.
 wyhan@sun.ac.za



Dr Joubert van Eeden
 SUPPLY CHAIN & LOGISTICS
 MANAGEMENT:
 Supply chain planning and analysis;
 Transport modelling, Logistics
 management.
 jveeden@sun.ac.za

Dr Theuns Dirkse-van Schalkwyk
 SYSTEMS MODELLING, SIMULATION AND
 DATA PROCESSING:
 Blockchain, business and other
 processes. RPA and data analysis.
 theuns@sun.ac.za



Ms Louzanne Bam
 HEALTH SYSTEMS MANAGEMENT:
 Operations research; Business process
 re-engineering; Simulation; Facility
 design; Project management; Operations
 management; Workforce planning.
 louzanne@sun.ac.za

Mr Wouter Bam
 INDUSTRIAL POLICY ANALYSIS:
 Mineral economics; Industrial policy;
 Value chains analysis; Sustainability
 assessment; Global production networks.
 wouterb@sun.ac.za



Ms Imke de Kock
 ENGINEERING MANAGEMENT AND
 SUSTAINABLE SYSTEMS:
 Technology management; Decision
 support; System dynamics & analysis;
 Sustainability science; Health systems
 engineering & innovation.
 imkedk@sun.ac.za

Mr Philani Zincume
 ENGINEERING MANAGEMENT:
 Frontline supervision, Engineering
 work teams, Human systems
 engineering, Production
 management; Rail engineering.
 philaniz@sun.ac.za



Mr Stephan Nel
 OPERATIONS RESEARCH:
 Mathematical modelling;
 Multi-objective optimisation;
 Machine learning; Data analytics.
 gsnel@sun.ac.za



The new Industrial Engineering building provides open plan office space for 180 postgraduate students.



The top-class boardroom with its spectacular view.

Mechanical and Mechatronic Engineering



On 2 January 2019, the SA Agulhas II pushed up against the bay ice at Penguin Bukta Antarctica. Here, scientists of the Department of Mechanical and Mechatronic Engineering got the chance to prepare their efforts for ice field work in the Weddell Sea. From the left: Prof Annie Bekker, James-John Matthee (graduate) and Christof van Zijl (master's student) used chainsaws to extract ice bending samples for mechanical testing of ice properties. The Weddell Sea Expedition departed from the shelf the next day to start its scientific programme.



Conference delegates at the official opening of the large fan and cooling system test facility situated at the Faculty of Engineering, Stellenbosch University.

Exceptional test facility opened at international conference

A large fan and cooling system test facility, the only one of its kind in the world, was officially opened at the Faculty of Engineering, Stellenbosch University, in November 2018. The axial flow fan in the facility is 7 m in diameter, powered by a 130 kW motor and has a novel, full-scale, delugeable heat exchanger.

This exceptional facility is part of the University's participation in the European-funded Horizon2020 MinWaterCSP Project. Its opening coincided with a two-day international conference on the reduction of water consumption in concentrating solar power plants, hosted in conjunction with Stellenbosch University.

The purpose of the conference was to introduce the South African industry and the wider international community to the project and the possible advantages that its results hold for the Concentrating Solar Power (CSP) industry.

The Horizon2020 MinwaterCSP Project could contribute to technologies that would significantly decrease water and energy consumption in power plants, while maintaining or possibly even improving net-power output to the client, especially in drought-stricken regions where CSP plants are customary.

Stellenbosch University is well known for its expertise in cooling technologies, as well as solar thermal energy

solutions and therefore made a significant contribution to the conference.

On the final afternoon of the conference, Prof Willie Perold (then Vice-Dean: Research and Industry Liaison, Faculty of Engineering) officially opened the new test facility.

This project has received funding from the European Union's Horizon2020 research and innovation programme under grant agreement No. 654443.

Prof Deborah Blaine elected as SAIMEchE President

Prof Deborah Blaine was elected as President of the South African Institution of Mechanical Engineering (SAIMEchE) for the period 2018 to 2020. She is an Associate Professor in the Department of Mechanical and Mechatronic Engineering at Stellenbosch University.

She has been involved in the South African Institution of Mechanical Engineering since 2008 and served as Chair of the Western Cape Branch between 2011 and 2013.

Regarding her election as SAIMEchE President, she says: "2018 has seen a couple of disturbing public comments regarding the place of women in science and technology. I am really pleased that SAIMEchE has chosen to elect me to represent our members at this time – it reflects my experience over the past 10 years of interaction with the institution, where I have

always been welcomed, encouraged, supported and acknowledged by my fellow mechanical engineering colleagues. We all know that the shape of society is changing faster than we can blink our eyes. SAIMechE has continued requests from our engineering student and early graduate engineer members for opportunities to engage with more experienced engineers, especially those who are qualified professionals (PrEng, PrTech), so that they can benefit from mentoring and insight into the profession. I hope that we can create these opportunities, to connect engineers from across the spectrum, in dynamic and interesting ways."

International recognition for solar thermal energy research at Stellenbosch

The Solar Thermal Energy Research Group (STERG) at Stellenbosch University has received international recognition for their research excellence and standing within the concentrating solar power (CSP) community. STERG has as a consortium member been selected to receive a \$2,0 million award from the United States of America (US) Department of Energy Solar Energy Technologies Office (SETO).

The consortium is led by SolarReserve, a worldwide developer of large-scale solar power projects and advanced solar thermal technology. SolarReserve is investor and technology provider to the South African Redstone CSP project. The third consortium partner is the US-based Sandia National Laboratories, offering the state-of-the-art concentrating solar power testing facilities at the National Solar Thermal Test Facility (NSTTF), operated by Sandia for the US Department of Energy.

Prof Johan van der Spuy, STERG Manager, says: "STERG has been actively involved in research on the utilisation of solar thermal energy for application in the fields of process heat and electricity generation. This funding creates a unique opportunity for South African researchers and engineers to apply their knowledge in taking part in the development of a next-generation heliostat system. Their involvement will build on experience gained during the Helio100 technology innovation project, funded by the Technology Innovation Agency, an initiative of the Department of Science and Technology."

The SETO award supports SolarReserve's development of a next generation heliostat system that aims to make substantial progress in cost reduction and performance for the concentrating system in a

solar power tower, aligned to the timing goals of the Energy Department's Generation3 Concentrating Solar Power Systems (Gen3 CSP) programme. Gen3 CSP projects are working to advance next-generation CSP systems that can operate at higher temperatures in order to store more heat, reducing the cost of CSP systems by increasing the efficiency of

the plant. Since the heliostat field can account for up to 50% of a CSP project's capital cost, it is a critical component in any cost reduction initiatives.

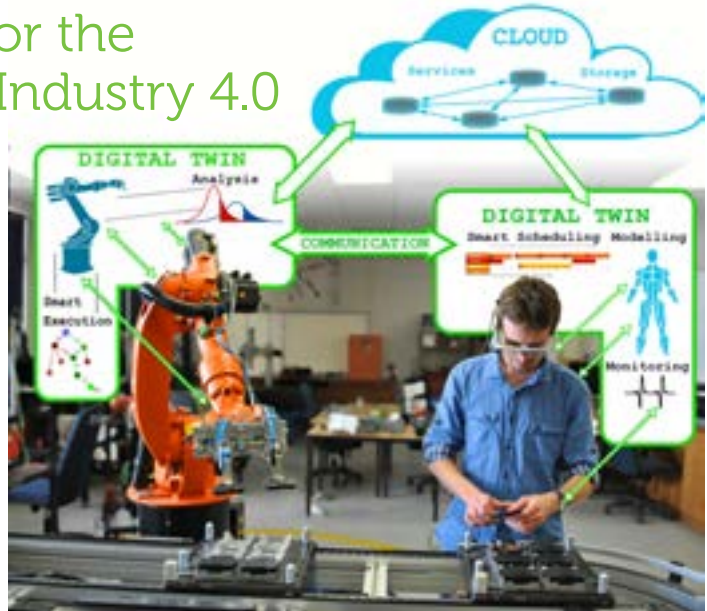
Dr Matti Lubkoll, Coordinator of STERG, says: "STERG has long held the belief that the key to unlocking the potential of concentrating solar power technologies in the South African context lies in cost reduction of the technology and its components. We are excited that our HelioPod technology was recognised to form part of this project to expand on its ability to reduce the cost of CSP while improving system performance. We are thankful to our funders, in particular the Department of Science and Technology and the Technology Innovation Agency that have proudly supported us and our research and development to date."

Research Output	
Journal Articles (subsidised)	45
Proceedings International	37
Proceedings National	17
Chapters in Books	2
Patents	1
Doctoral completed	5
Master's completed	51



Digital Twins for the South African Industry 4.0

Digital Twins in action – machines and people working together, connected through their data-driven digital representations.



The whole world is buzzing over the fourth industrial revolution, but what is it really? And when is it coming to South Africa?

Industrial revolutions have always followed the implementation of new technology; changing the way industries make and do things. First it was the introduction of steam-powered machines, then production lines, and then computers – now it is the Internet. The fourth industrial revolution (or Industry 4.0) will be driven by the use of the Internet and Internet services to enhance the connectedness of machines, systems and people.

Industry 4.0 relies on several important technologies, like the *Internet of Things*, *Big Data* and *Cyber-Physical Systems*. But how can we combine these technologies to add value? *Digital Twins* – the idea of creating a virtual representation of real-world entities to integrate them in a digital world – is a developing idea for combining these enabling technologies for Industry 4.0.

At the Department of Mechanical and Mechatronic Engineering, the Mechatronics, Automation and Design Research Group focuses on the development of Digital Twins to enable Industry 4.0 for the South African context. In South Africa, industries must improve their production throughput, quality and agility – all while operating under severe socio-economic pressure. The effective implementation of Digital Twins can improve the global competitiveness of South African enterprises, while addressing important social concerns.

Considering the importance of developing human capital and creating and retaining jobs in South Africa, the research also considers the Digital Twin concept for human workers. Digital Twins have the potential to effectively integrate manual labour in modern industries – facilitating enhanced efficiency, quality and flexibility. The approach to integrating humans in Industry 4.0 is to retain and leverage the inherent human strengths, while compensating for their weaknesses through digital representation and integration.

Their research currently explores several exciting technologies for implementing Digital Twins, such as:

- Collaborative robots that can share their workspaces with human workers safely.
- Augmented reality to integrate humans and digital systems.
- Communication and cloud platforms to effectively manage data and connect networks of systems and people.
- Programming languages for creating massively scalable, robust software to support Digital Twin implementation.

Recent years have seen a growing interest from South African industries in Digital Twins and Industry 4.0. Currently their research considers applications in the domains of manufacturing, marine assets and agriculture, while interest also exists in the mining, food processing and logistics industries.

Energy and the Environment

In close collaboration with the Centre for Renewable and Sustainable Energy Studies, the Department contributes towards fundamental research into a wide range of energy generation technologies. Addressing transport needs, the group investigates the performance and impact of biofuels and blends in compression-ignition and spark-ignition engines. Uniquely South African solutions to concentrating solar thermal power and energy storage systems are researched. The group's world-leading research in air-cooled heat exchangers and cooling towers is well known. Excellent experimental capabilities and strong computational expertise enable the group to develop special fans, compressors and turbines, e.g. ocean current, wind, and solar energy exploitation-, and air-cooled systems. Research covering the energy efficient design of ship propulsion, ship hulls and various turbomachinery is supported by the only 90 m long towing tank in Southern Africa. The Department boasts the largest fan test facility (7 m diameter) in South Africa.

Mechanics and Dynamics

Activities are divided into fundamental research on materials, behaviour of structures and failure mechanisms and criteria. The materials research focuses on powder metal processing and products, material property extraction using digital image and volume correlation, characterisation of granular materials and qualification of additive manufactured parts. The structures research looks for fundamental understanding of the behaviour of structures under static and dynamic conditions and, in the case of vehicles, aircraft or ships, their impact on humans. Failure mechanisms and criteria of composite materials and fracture and creep deformation of steels are researched.

Mechatronics, Automation and Design

Diverse mechatronic systems such as reconfigurable manufacturing systems, unmanned aerial vehicles, robots and medical devices are researched. Practical solutions to the challenges of Industry 4.0 are found. It finds applications in automation of assembly systems, digital twins, inspection and quality control using machine vision and calibration and maintenance of heliostats for concentrating solar power systems.

Computational Modelling

The group's expertise in optimisation theory and algorithm development, finite element methods (FEM), computational fluid dynamics (CFD), discrete element methods (DEM) and continuum methods is world-renowned. The DEM work is applied to mining and earthmoving equipment, particle dampers, conveyors, etc. The optimisation methods are often linked to the FEM and CFD work in applications related to fluid structure interaction, turbomachinery, combustion and various renewable energy technology applications. The group also has expertise in the modelling and simulation of metal casting processes with emphasis on solidification analysis and segregation.

Biomedical Engineering

Technologies such as 3D printing, microcomputers and artificial intelligence are opening up new opportunities for engineering in the biomedical field. This group is developing innovative minimally invasive devices to collect healthcare information, mechatronic devices for telemedicine and finding customised solutions for the treatment of specific diseases as well as developing and testing medical sensors for in vivo testing of the human knee's biomechanical properties.

Design and Mechatronics

Chair
Prof Kristiaan Schreve

MECHANICAL AND
MECHATRONIC DESIGN:
Micrometrology; Machine vision;
Reverse engineering.
kschreve@sun.ac.za



Prof Anton Basson

MECHANICAL AND
MECHATRONIC DESIGN:
Design for manufacturing;
Distributed control systems;
Automation of manufacturing.
ahb@sun.ac.za

Prof Pieter Fourie

BIOMEDICAL ENGINEERING:
Conceptualisation, research
and development of innovative
technologies for the South African
societal needs.
prfourie@sun.ac.za



Prof Nawaz Mahomed

COMPUTATIONAL MECHANICS:
Metal casting; Heat treatment; Barrier
coatings; Computational mechanics.
nawaz@sun.ac.za

Prof Corné Coetzee

MODELLING OF GRANULAR FLOWS:
Meshless finite element and discrete
element method.
ccoetzee@sun.ac.za



Prof Martin Nieuwoudt

DIRECTOR: Institute for Biomedical
Engineering.
Device regulation education, Human
capacity development, Biostatistical
and molecular research.
mnieuwoudt@sun.ac.za

Prof Dawie van den Heever

BIOMEDICAL ENGINEERING:
Neural engineering; Neuroscience;
Artificial intelligence; Medical devices.
dawie@sun.ac.za



Dr Danie Els

MECHANICAL DESIGN:
Modelling of granular flows and
particle dampers; Infantry weapon
systems and fuze design.
dnjels@sun.ac.za

Dr Karel Kruger

MECHANICAL AND
MECHATRONIC DESIGN:
Design, control, manufacturing and
assembly systems; Industrial robot
programming; Machine vision.
kkruger@sun.ac.za



Dr Jacques Muiyser

AEROELASTICITY AND
STRUCTURAL DYNAMICS:
Measurement and analysis of air-
cooled heat exchanger fan system
dynamics and vibration.
jmuiyser@sun.ac.za

Dr Willie Smit

MECHATRONICS:
Unmanned aerial vehicles;
Heliostat control and calibration
wjsmit@sun.ac.za



Dr Johan van der Merwe

BIOMEDICAL ENGINEERING:
Patient-specific orthopaedic
implant and instrument design;
Statistical shape modelling.
jovdmerwe@sun.ac.za

Ms Liora Ginsberg

MECHANICAL DESIGN:
Biomechanics; Biofluids.
ginsberg@sun.ac.za



Mr Gareth Erfort

AEROELASTICITY AND FLUID
DYNAMICS:
Open source CFD; Robotics;
Wind energy.
erfort@sun.ac.za

Mr Otto Scheffler
MODELLING OF PARTICLE FLOWS:
Application of the Discrete Element
Method to agricultural systems.
ocscheffler@sun.ac.za



Mr Piero Trincherio
MECHANICAL DESIGN:
Engineering drawing,
CAD and machine design.
ptrincherio@sun.ac.za



Thermo-Fluids

Prof Thomas Harms
ENERGY SYSTEMS:
Computational fluid dynamics;
Renewable energy.
tmh@sun.ac.za



Prof Theo von Backström
TURBOMACHINERY:
Fan design; Solar thermal energy
systems; Fluid mechanics;
Ocean energy.
twvb@sun.ac.za



Prof Johan van der Spuy
FLUID MECHANICS AND
TURBOMACHINERY:
Axial flow fans; Micro gas turbine
development; Centrifugal
compressor development.
sjvdsput@sun.ac.za



Prof Christiaan Meyer
MULTIPHASE FLOWS:
Mineral processing; Particulate
dispersion and suspension;
Non-Newtonian behaviour of
multiphase fluids; Combustion.
cjmeier@sun.ac.za



Prof Craig McGregor
ENERGY SYSTEMS:
Renewable energy;
Concentrating solar thermal.
craigm@sun.ac.za



Dr Michael Owen
HEAT TRANSFER AND FLUID
DYNAMICS:
Industrial heat exchangers;
Thermal energy systems;
Aerodynamics.
mikeowen@sun.ac.za



Dr Jaap Hoffmann
THERMODYNAMICS, HEAT
TRANSFER AND FLUID DYNAMICS:
Computational fluid dynamics;
Dispersed two-phase flow.
hoffmaj@sun.ac.za



Mr Richard Haines
INTERNAL COMBUSTION ENGINES:
Compression-ignition and spark-
ignition engine performance
evaluations of biofuels and blends.
rhaines@sun.ac.za



Mr Carl Tshamala
THERMODYNAMICS AND
HEAT TRANSFER:
Power generation; Cooling
systems performance
evaluation and optimisation for
industrial applications.
mctshamala@sun.ac.za



Mr Matthew Meas
HEAT TRANSFER AND FLUID
DYNAMICS:
Concentrating solar power systems;
Solarised gas turbines.
mmeas@sun.ac.za



Mechanics

Prof Gerhard Venter
COMPUTATIONAL MECHANICS:
Structural analysis and
optimisation; Multidisciplinary
optimisation.
gventer@sun.ac.za



Prof Albert Groenwold
MATHEMATICAL &
COMPUTATIONAL MODELLING:
Structural and multidisciplinary
analysis and optimisation;
Artificial intelligence.
albertg@sun.ac.za

Prof Deborah Blaine
MATERIALS ENGINEERING:
Powder and particulate materials;
Characterisation of material
properties; Material development.
dcblaine@sun.ac.za



Prof Annie Bekker
SOUND AND VIBRATION:
Measurement; Human response;
Order analysis and signature testing;
Modal testing; Automotive NVH.
annieb@sun.ac.za

Prof Thorsten Becker
MATERIALS ENGINEERING:
Fracture; Damage; Characterisation
of material properties; Digital
correlation; Selective laser melting.
tbecker@sun.ac.za



Dr Martin Venter
COMPUTATIONAL MECHANICS:
Structural analysis; Inflatable structures;
Materials characterisation;
Textile composites.
mpventer@sun.ac.za

Prof Wikus van Niekerk
RENEWABLE AND
SUSTAINABLE ENERGY:
Solar, ocean and wind energy,
for both utility and small-scale
electricity generation.
wikus@sun.ac.za



Mr Raymond Botete
MATERIALS ENGINEERING:
Characterisation of material
properties; Selective laser
melting; Material development.
mrbotete@sun.ac.za



Mr Llewellyn Cupido
MATERIALS ENGINEERING:
Metal casting; Heat treatment;
Mechanical metallurgy.
llcupido@sun.ac.za

Process Engineering



High-value products and biofuel production from photosynthetic microorganisms is a promising research field. A team under the supervision of Dr Robbie Pott have been involved in the design, manufacturing and testing of an Outdoor Bubble Column Photobioreactor. At the bioreactor manufactured in the Process Engineering Workshop are from the left Hester Stofberg (final year), Bovinille Anye Cho (2018 MEng *cum laude* graduate), Fred Spackman (visiting researcher from the University of East Anglia, UK) and Jos Weerdenburg (Chief Mechanician).



Prof Cara Schwarz with her postgraduate students.

Prof Cara Schwarz first female full professor in Engineering at Maties

When Cara Schwarz kicked off her studies in 1996 as a first-year Maties Chemical Engineering student, she had no idea that one day she would become the first female full professor in Engineering at Stellenbosch University.

"I have always been fascinated by how things come together and how they work technically," she says. "I also liked Chemistry at school and therefore I opted for Chemical Engineering at Stellenbosch University as I felt this degree programme was ideal to include both my interests."

Prof Schwarz is a full-blooded Matie. She obtained all her degrees from Stellenbosch University: BEng (Chemical) in 1999, MScEng in Chemical Engineering *cum laude* in 2001 and PhD in 2005. Thereafter she worked as a postdoctoral fellow at her alma mater for five years. She progressed through the ranks as senior researcher and associate professor until her appointment on 1 October 2018 as full professor.

Even in her capacity as a senior researcher, she lectured classes. She says: "Although my interest inclines slightly towards research and its technical aspects, I thoroughly enjoy to lecture to students and to see how they develop and mature. I try to maintain a balance between research and lecturing, because I have to cultivate an interest for my field amongst students on an undergraduate level already."

Prof Schwarz's field of expertise is thermodynamics and its impact on separation processes with particular focus on high pressure/supercritical and advanced distillation processes. "During my postgraduate studies I really enjoyed doing research and could picture myself in a research-oriented career."

Prof Schwarz has already made her mark in her field. In July 2018 she was recognised by the international

Journal of Chemical Engineering as one of 25 researchers who will be defining the field over the coming years (in an edition that focuses on emerging investigators in chemical thermodynamics). Prof Schwarz also serves on the editorial advisory board of this publication.

She is respected by her peers. The Chair of the Department of Process Engineering, Prof André Burger, speaks highly of her as he notes: "Cara has established herself as a highly respected and competent academic at the Department of Process Engineering and we are proud to have her as a colleague. She does not shy away from hard work or responsibilities and her excellent research record is proof of her intelligent dedication."

Research Chair in Sugarcane Biorefining

In 2018, a DST/NRF SA Research Chair in Sugarcane Biorefining was established in the Faculty of Engineering at Stellenbosch University. It is held by Prof Johann Görgens, head of the Bioresource Engineering Group in the Department of Process Engineering.

The Chair aims to broaden the range of products manufactured from available sugarcane to maximise the economic value extracted beyond conventional products like sugar, electricity and ethanol.

The focus of the Research Chair will be on biomass fractionation, separation, conversion, value addition and new product development. One of the key elements will be to facilitate training of sugarcane biorefining scientists and engineers, especially at master's and PhD levels. Postdoctoral researchers will also facilitate postgraduate programmes through supervision and mentoring.

Although the South African sugarcane processing industry is considered highly efficient despite the high

cost of cane, it has become clear that breakthrough and even disruptive technologies are required in order to remain competitive and sustainable.

Prof Görgens says: “The new research chair aims to address the core challenge that the sugar industry has faced for some time, which is the need to expand the range of valuable products obtained from sugar cane. This requires extensive assessment and development to ensure that new, sustainable business opportunities are created for the industry, which is what the chair aims to contribute to.”

The challenges facing the South African sugar industry are not unique. Sugarcane industries worldwide have been exploring the concept of an integrated biorefinery approach, in which sugarcane is viewed as a source of biomass that can be processed to produce multiple, value-added chemical and energy products.

The existing sugarcane industry is well-placed to embrace the biorefinery approach as raw sugar mills already have appropriate infrastructure in place for collecting and processing bulk biomass, which confers a major advantage over processing of other lignocellulosic feedstocks. In addition, a sugarcane biorefinery should be self-sufficient in terms of outside energy supplies, thereby reducing processing costs and minimising exposure to fluctuations in fuel costs.

The development of these new technologies is multidisciplinary and considerable collaboration is required with other engineering disciplines (mechanical and electronic), scientific disciplines (chemistry, physics and microbiology) as well as economics, in order to develop sound techno-economic justifications for the most promising products and technologies. Prof Görgens has longstanding collaboration with the Sugar Milling Institute, RCL Foods, and the Universities of KwaZulu-Natal, Cape Town and Fort Hare. Future cooperation will be extended to include local and international collaborators.

At the end of 2022, the Chair in Sugarcane Biorefining will be renewable for two further five-year periods.

ARUA

Personnel in this Department are playing a prominent role in the African Research Universities Alliance (ARUA) launched in 2015, with 16 Universities from across

Africa currently comprising the alliance. Countries include, South Africa, Nigeria, Ghana, Tanzania, Kenya, Rwanda, Senegal, Uganda an Ethiopia.

In order to facilitate research networks, ARUA identified thirteen research areas, which include fields such as Climate change, Food security, Non-communicable diseases, Materials development and nanotechnology, Water conservation, Energy, Poverty and inequality, and Good governance, to name a few. As member of ARUA, Stellenbosch University actively participates in activities of the alliance.

In the latter part of 2017, ARUA launched the call for ARUA members to indicate their interest to host the secretariat of a Centre of Excellence (CoE), based on the 13 thematic areas. Following the internal and external evaluation of the applications in September

2017, it was recommended that SU host the Secretariat of the ARUA Energy CoE. This was ratified at the end of January 2018. Co-coordinators for the CoE are Prof Johann Görgens and Prof Sampson Mamphweli. A proposal-writing workshop was held in Stellenbosch from 20 to 24 August 2018, bringing together close to 60 researchers from ARUA member institutions. The workshop resulted in eight consortium-based proposals, and strengthened partnerships and collaboration between the different institutions. These projects will subsequently be adapted according to specific funding opportunities for collaborative work between the universities.

Research Output	
Journal Articles (subsidised)	56
Proceedings International	12
Proceedings National	2
Chapters in Books	4
Doctoral completed	8
Master's completed	32



Prof André Burger
Chair: Process Engineering.

“Awesome” seaweeds researched in ambitious, collaborative project



Zwonaka Mapholi (master's student) investigating how the extraction of high-value fucoidan from kelp can be enhanced through ultrasonication.

Do you regard seaweeds as special? If not, you are part of a rapidly shrinking group of the global population. The reason for this is simple: *Seaweeds are awesome!*

Worldwide, the industry, academia and the wider public realise that as a strategic source, seaweeds can help to solve problems related to sustainable industrial development and environmental degradation. It can also enable us to move away from an economy based on fossil fuels. We know seaweed contains a variety of useful compounds, some of which cannot be found in any plants grown on land. We know seaweeds grow very fast, require no fertilisers to be farmed and do not compete for farmland or freshwater. Furthermore, many species are already farmed on a large scale in different parts of the world. What we do not know (yet), is how to best process seaweeds to recover both valuable compounds and bioenergy, in order to make the most efficient use of every single piece that gets harvested.

The sustainable processing of a major South African seaweed, kelp, is the topic of an ambitious, collaborative project in the Department of Process Engineering, coordinated by Dr Neill Goosen. The project is a partnership between Stellenbosch University, a local company, CMD Industries, and the Cape Peninsula University of Technology (CPUT). The aim is firstly to explore how to recover different high-value and health-promoting compounds found in kelp by optimising different environmentally friendly processing methods. Secondly, it is to determine how these compounds can be incorporated into existing

foods (ranging from health bread to ice-cream) without compromising consumer acceptability. All of this needs to be accomplished with minimal use of water and energy in processing, while utilising the maximum amount of the raw material fed into a commercial production process.

Results thus far are preliminary, but extremely encouraging, especially in terms of the recovery of different polysaccharides found exclusively in seaweeds. Fucoidan, laminarin and alginate have very specific properties, and methods to recover these via enzymatic methods or solvent-free water extractions are currently being optimised. Residues from these extractions are being converted into bioenergy via anaerobic digestion, while the extracted material is being tested in food systems and for their ability to help synthesise nanoparticles with particular properties.

After all the finer science has been done, the overall aim of developing a commercially viable processing plant still needs to be accomplished. To achieve this, all the different processing methods are being combined into a techno-economic viability study to determine which combination of processing methods and conditions will result in the most profitable plant. The first results are being presented at different conferences during 2019, and hopefully some interesting journal papers will see the light soon.

So, if you are not on the seaweed party boat yet, you better get aboard before space runs out. We may not know everything about seaweeds yet, but one thing we do know is that seaweeds are awesome!

Extractive Metallurgy

The sustainable production of valuable minerals and metals from ore or metal-containing waste material is critical for a sustainable future. Ore is a complex raw material, requiring a wide variety of treatment processes to unlock valuable minerals and metals. The group undertakes research into the fundamental concepts and application of such treatment processes. Key challenges include changing raw material characteristics due to depletion of easy-to-access ore bodies, minimisation of energy and water usage, as well as effectively dealing with the complex behaviour from the intricate flowsheets required.

Waste Valorisation

The successful valorisation of wastes will allow closing the loop in the circular economy, moving closer to a sustainable future. Key challenges include separation and concentration of valuable products as well as functionalisation of relatively inert chemicals. Main focus areas include:

- * Waste tyre and waste plastic conversion to high-value chemicals.
- * Electronic waste processing for metal recovery (lithium, gold, copper).

Separations Technology

The Separations Technology research group focuses on understanding the fundamentals and thermodynamics of separation processes involving hydrocarbons. Typical processes include distillation, liquid-liquid extraction, adsorption, supercritical fluid fractionation and membrane separation. Much of the work is focused on the separation of compounds where the underlying systems may exhibit azeotropy and association due to hydrogen bonding, and where the systems may involve molecules with varying polarity and asymmetrical structure.

Bioresource Engineering

To ensure a sustainable future, biological resources need to be used optimally. This group focuses on developing industrial bioprocesses that are safe, sustainable and profitable, either through processes that employ biological resources (e.g. live organisms or active biological molecules) to transform raw materials into valuable products, or production processes that use biological raw materials as inputs. There is a strong interdisciplinary focus within the group, and frequent collaboration occurs with other disciplines at Stellenbosch University and with leading foreign institutions.

Water Technology

The group focuses on research and development aimed at addressing local and international challenges in water provision. The objective is to improve existing water treatment technologies as well as develop new technologies that will contribute to addressing this global challenge. The group's strengths include membrane technology (microfiltration, ultrafiltration, reverse osmosis, forward osmosis, membrane distillation and Donnan Dialysis), and in technologies that will be applicable in developing economies. Current projects range from investigation and modelling of basic phenomena, to technology development leading to implementation in the field.

Process Monitoring and Machine Learning

Advances in online monitoring and data collection present an opportunity to enhance the efficiency, sustainability and profitability of chemical engineering processes. This group focuses on the use of machine learning techniques to improve the operation and control of chemical plants, with an emphasis on producing industry ready solutions. Applications include fault detection and diagnosis, causality analysis, operational state identification and actionable advisories.

Chair

Prof André Burger

SEPARATIONS TECHNOLOGY:
Desalination and water treatment;
Distillation hydrodynamics;
Thermodynamics and phase equilibria.
ajburger@sun.ac.za



Prof Hansie Knoetze

SEPARATIONS TECHNOLOGY:
Supercritical fluid extraction;
Thermodynamics and high
pressure phase equilibria; Column
hydrodynamics; Rocket propulsion.
jhk@sun.ac.za



Prof Steven Bradshaw

EXTRACTIVE METALLURGY:
Hydrometallurgy; Pyrometallurgy;
Machine learning;
Microwave processing.
smb@sun.ac.za



Prof Johann Görgens

SARCHI RESEARCH CHAIR:
Sugarcane Biorefining.
BIORESOURCE ENGINEERING:
Waste valorisation; Development
of biorefineries; Second generation
biofuels; Industrial enzyme production.
jgorgens@sun.ac.za



Prof Guven Akdogan

EXTRACTIVE METALLURGY:
Mineral processing;
Extractive processing;
Waste processing
and recycling.
gakdogan@sun.ac.za



Prof Sampson Mamphweli

DIRECTOR: Centre for Renewable and
Sustainable Energy Studies
BIOMASS AND BIOENERGY
TECHNOLOGIES:
Waste to energy technologies; Biogas
digesters; Biomass gasification.
mamphweli@sun.ac.za



Prof Cara Schwarz

SEPARATIONS TECHNOLOGY:
Supercritical fluid extraction;
High pressure phase equilibria;
Low pressure phase equilibria;
Thermodynamics; Waste valorisation.
cswartz@sun.ac.za



Prof Lingam Pillay

WATER TECHNOLOGY:
Wastewater remediation and reuse;
Rural water treatment; Membrane
technology; Novel water treatment
processes.
pillayvl@sun.ac.za



Prof Christie Dorfling

EXTRACTIVE METALLURGY:
Hydrometallurgy; Metal recycling;
Process modelling; Waste valorisation.
dorfling@sun.ac.za



Dr Annie Chimphango

BIORESOURCE ENGINEERING:
Biomass processing; Bioprocess
engineering; Postharvest
engineering; Sustainable bioenergy
systems; Sustainable biomaterials.
achimpha@sun.ac.za



Dr Neill Goosen
 BIORESOURCE ENGINEERING:
 Waste valorisation;
 Aquaculture nutrition;
 Biological waste utilisation.
 njgoosen@sun.ac.za



Dr Tobi Louw
 BIORESOURCE ENGINEERING:
 Multiscale mathematical modelling
 of biological processes; Process
 monitoring and data analysis.
 tmlouw@sun.ac.za

Dr Robbie Pott
 BIORESOURCE ENGINEERING:
 Bioprocess engineering; Biofuels;
 Waste valorisation; Biorefineries.
 rpott@sun.ac.za



Dr Eugene van Rensburg
 BIOPROCESSING:
 Biomass processing; Fermentation;
 Anaerobic digestion.
 eugenevrb@sun.ac.za

Dr Margreth Tadie
 EXTRACTIVE METALLURGY:
 Surface science; Electrochemical
 processes; Electrometallurgy.
 mtadie@sun.ac.za



Dr LJ du Preez
 SEPARATIONS TECHNOLOGY:
 Mass-transfer and adsorption.
 ljdupreez@sun.ac.za

Dr Jamie Cripwell
 SEPARATIONS TECHNOLOGY:
 Thermodynamic modelling; Statistical
 associating fluid theory; Low pressure
 phase equilibria; Thermophysical
 property measurement.
 cripwell@sun.ac.za



Ms Sunel Nortjé
 SEPARATIONS TECHNOLOGY:
 Thermodynamic modelling;
 Sustainability and environmental
 engineering; Energy efficiency and
 reduction of greenhouse gas emissions.
 snortje@sun.ac.za



Mr Petrie van Wyk
 EXTRACTIVE METALLURGY:
 Mineral processing;
 Hydrometallurgical extraction
 processes.
 apvanwyk@sun.ac.za

Outreach Programmes



At a special event in March 2018, the Faculty of Engineering acknowledged school principals, their management teams, parents and learners for their outstanding academic results in the 2017 Matric examinations. During the function, certificates of recognition were handed over to 49 schools on the Western Cape Education Department's merit list. From the left representatives of COSAT High, South Peninsula High and Protea Heights Academy receive their certificates from the Dean of Engineering, Prof Wikus van Niekerk.

Open Day

The annual Open Day makes learners, parents and the general public aware of the interesting world of the engineer and the vast career opportunities in this field.

Enquiries: Ms Tanya Ficker

Tel: +27 21 808 9403, e-mail: tanya@sun.ac.za

Engineering Winter Week

During the annual Winter Week, Grade 11 and 12 learners get a clear picture of the work of an engineer through presentations by lecturers and engineers, as well as visits to industries and laboratories.

Enquiries: Ms Portia Adonis

Tel: +27 21 808 4203, e-mail: winterweek@sun.ac.za

Women in Engineering

At the annual Women in Engineering afternoon, Grade 10 to 12 girls, who excel in Mathematics and Physical Sciences, find out more about engineering as a career for women when women engineers, lecturers and students address them.

Enquiries: Mr August Engelbrecht

Tel: +27 21 808 4203, e-mail: august@sun.ac.za

Top Achiever Sessions

During sessions presented in Stellenbosch and various major cities countrywide, top achievers (Grade 11 and 12) and their parents are informed about engineering as a career and the Faculty's degree programmes.

Enquiries: Mr August Engelbrecht

Tel: +27 21 808 4203, e-mail: august@sun.ac.za



The popular Open Day is a massive team effort between personnel and students and is well attended by learners, parents, teachers and the general public. Here students in the Department of Civil Engineering address the visitors in the Structure Laboratory.

First Generation Experience

Universities can be quite daunting if you have no experience of academic or tertiary institutions. In 2018 the Faculty launched this new outreach for Grade 11 and 12 top achievers, whose parents have not had the opportunity to study at a university. During a day visit they feel the exciting vibe of campus, hear about the Faculty's degree programmes and other SET fields of study and meet the Dean.

Enquiries: Mr August Engelbrecht

Tel: +27 21 808 4203, e-mail: august@sun.ac.za

Buddy Programme to facilitate integration

Engineering is a demanding and challenging programme and many first generation students (in particular those who do not stay in a university residence) find it difficult to adapt to the new environment and academic culture. During the first semester, senior students act as the students' "buddies" to facilitate their smooth integration.

Enquiries: Mr August Engelbrecht

Tel: +27 21 808 4203, e-mail: august@sun.ac.za

Leadership Development

Senior students follow a leadership module at the Frederik van Zyl Slabbert Institute for Student Leadership Development, which enables them to become well-rounded engineers who are better equipped to make a difference in society.

Enquiries: Ms Avril Ford

Tel: +27 21 808 3614, e-mail: aford@sun.ac.za



The SUNSTEP Programme provides learners the opportunity to build their own working electronic circuits. Learners look with rapt attention while Miranda Myburgh demonstrates the steps they have to follow.

TRAC South Africa

The TRAC Programme, the biggest community interaction programme at Stellenbosch University, gives support in Physical Sciences and Mathematics in TRAC laboratories countrywide to learners in disadvantaged communities. It also provides vocational guidance regarding careers in the sciences, engineering and technological fields and assists learners to obtain funding for tertiary studies.

Enquiries: Ms Debbey Olivier

Tel: +27 21 808 4384, e-mail: debbey@sun.ac.za

SUNSTEP

The SUNSTEP Programme provides learners the opportunity to build their own working electronic circuits. There are also workshops for educators.

Enquiries: Ms Miranda Myburgh

Tel: +27 21 883 8182, e-mail: mmyburgh@sun.ac.za

CRSES Schools' Programme

This programme, run by the Centre for Renewable and Sustainable Energy Studies, provides professional development and learning material (free of charge) to assist educators in teaching renewable energy topics. It is implemented in collaboration with the Department of Education, WESSA Eco Schools, Fundisa for Change, Science Centres and Independent Power Producers.

Enquiries: Prof Sampson Mamphweli

Tel: +27 21 808 4069, e-mail: mamphweli@sun.ac.za

Minquiz

Minquiz (organised by Mintek) is a science and technology quiz for Grade 12 learners that promotes careers in science and technology, especially in mining, mineral processing and geology. The Department of Process Engineering provides assistance in the Boland and the Western Cape.

Enquiries: Prof Christie Dorfling

Tel: +27 21 808 3674, e-mail: dorfling@sun.ac.za

Postal address	Posadres
Faculty of Engineering	Fakulteit Ingenieurswese
Stellenbosch University	Universiteit Stellenbosch
Private Bag X1, Matieland 7602, South Africa	Privaat Sak X1, Matieland 7602, Suid-Afrika
Street address	Straatadres
Cor. Banghoek Road and Joubert Street	H/v Banghoekweg en Joubertstraat
Stellenbosch	Stellenbosch
Telephone	Telefoon
+27 21 808 4203	+27 21 808 4203
Coordinates	Koördinate
33° 55' 45" S	33° 55' 45" S
18° 51' 54" E	18° 51' 54" O

www.eng.sun.ac.za